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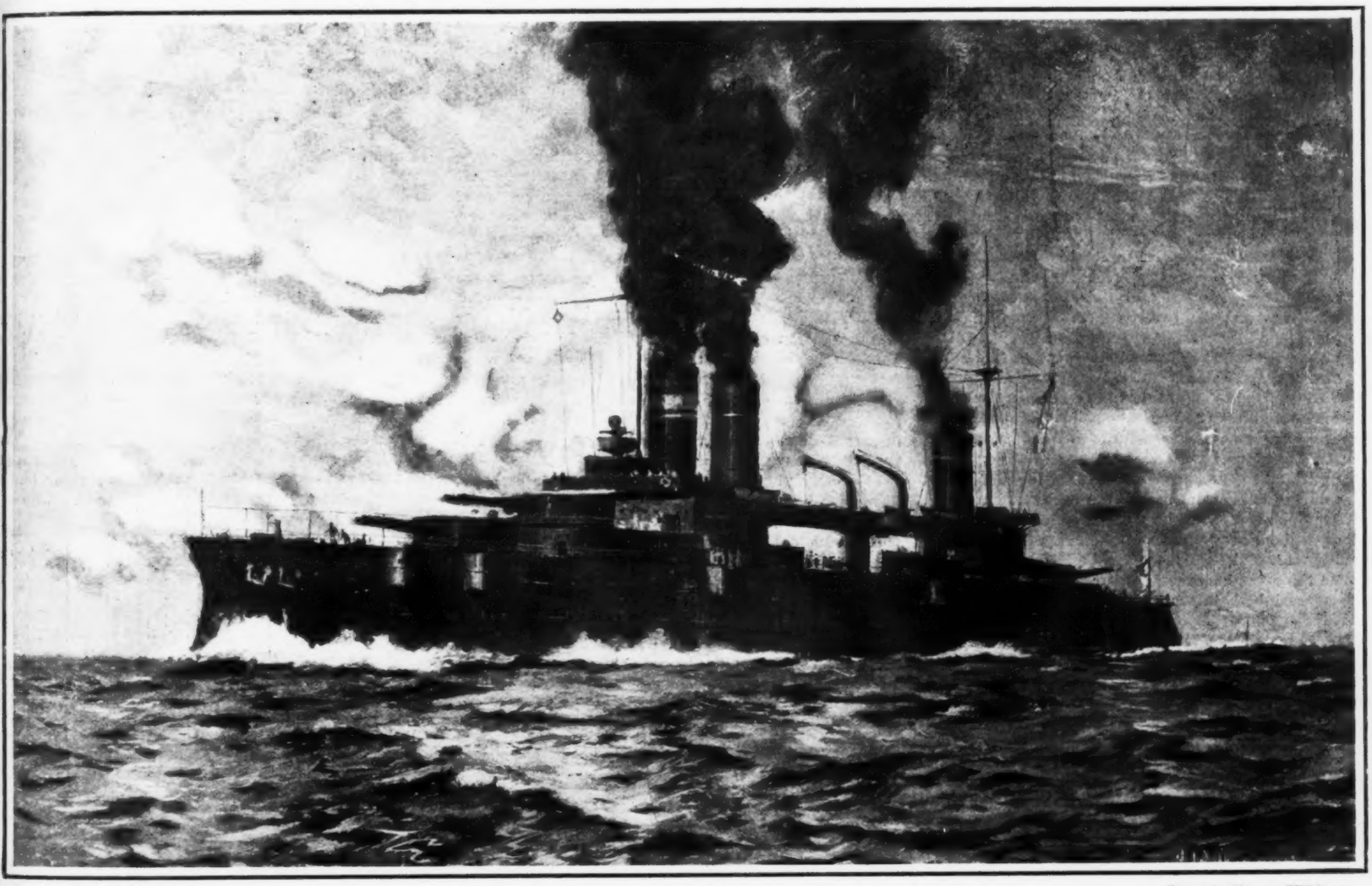
## THE NEW GERMAN BATTLESHIP "ERSATZ-BAYERN."

In the launch of the "Ersatz-Bayern" last month Germany set afloat the first of the many "Dreadnoughts" which she is either now building or has in contemplation. Of the several vessels of this type which have been designed or built by the various governments during the past two or three years, there is none about which more uncertainty has existed than the German ships. Indeed, the Germans are even more successful than the Japanese in maintaining secrecy regarding their naval designs; and they have managed to keep even the principal features of the "Ersatz-Bayern" and her sister ships from becoming a matter of public knowledge. Generally speaking, these ships have been credited with carrying a battery of sixteen 11-inch, 50-caliber guns on a displacement of less than 18,000 tons, the guns being mounted, according to one well-known high-class English naval annual, in six turrets; two of them carrying a pair of guns, and four of them mounting each three 11-inch guns. We have never believed that the Germans would put three big guns in one turret, when it is well known that the ideal mounting for efficiency is one gun in one turret. Moreover, it would seem to be a physical impossibility to mount sixteen 11-inch guns on an 18,000-ton ship without making serious sacrifices in armor, motive power, or strength of hull structure. The German 11-inch gun of 50 calibers weighs 49 tons; the American 12-inch gun of 45 calibers weighs only one ton more, 50 tons. Now, our new ships, the "Delaware" and "North Dakota," are to mount only ten 12-inch guns, and how can it be possible for the "Ersatz-Bayern" of 2,000 tons less displacement to carry sixteen weapons of about the same weight?

Hence we are inclined to think that the accompanying illustration, which is made from a fine painting by N. Wilkinson, the well-known artist and naval expert, is probably nearer the truth. It shows the "Bayern" as mounting ten 11-inch guns: four forward in two turrets; two on either beam amidships and two astern. According to the drawing, the guns are to have an exceedingly high command, all being carried on a spar deck, whose freeboard would seem to be about 28 feet, the freeboard being maintained aft to the quarter deck, where it is cut down to apparently about 19 feet. The other vessels of this class are the "Ersatz-Sachsen," the "E. Baden," and "E. Wurttemburg," the first being built by Weser at Bremen, the "Bayern" at Wilhelmshaven, the "E. Baden" at the Vulcan Works, Stettin, and the "E. Wurttemburg" by Krupps at the Germania Works. Some of the ships are to be propelled by turbine engines, and they are all designed to steam at 19 knots with 24,000 horse-power. In addition to the 11-inch guns, they will carry a numerous battery of small rapid-fire guns for repelling torpedo attack, some in sponsons on the main deck, and the others upon the bridge deck. The thickness of the armor is uncertain, but it will probably be from 9 to 12 inches at the water line, with 10 to 12 inches protection to the main battery.



From the Illustrated London News. Drawn by Norman Wilkinson.

THE NEW GREAT GERMAN BATTLESHIP "ERSATZ-BAYERN" AS SHE WILL APPEAR WHEN COMPLETED.

The launch of the "Ersatz-Bayern" (replacing the "Bayern") took place at Wilhelmshaven on March 5. The vessel's displacement is 17,960 tons, and her minimum speed is to be 19 knots. Her crew will number 866, including 27 officers. Her armament is variously stated at from ten to sixteen 11-inch guns. The cost of her construction, including trial runs, will be $9,190,000. The "Ersatz Bayern" is the first installment of Germany's reply to the "Dreadnought" class.

## MODERN NITER BEDS.*

Ever since the invention of "villainous saltpeter," the provision of a sufficiency of nitrates has been one of the preoccupations of a ministry of war, and the necessity has become greater rather than less under the conditions of modern warfare. The potassium nitrate that was required for the fabrication of gunpowder is now replaced by the nitric acid used in making the various types of nitro-explosives, but it is always the nitric ion that has to supply the oxygen, and the consumption in a modern battle attains a magnitude of which our immediate predecessors using black powder had no conception. Indeed, one truly scientific argument against war may be drawn from the enormous losses it occasions in the world's limited stock of combined nitrogen.

Up to the middle of the nineteenth century, India was the only source of nitrates on a large scale, and though a certain amount of niter was recovered from the efflorescence of the walls of cellars and from artificially made beds of earth mixed with decaying animal matter, it was not until the closing of the seas to France during the wars of the Directory that the necessity of an internal supply of nitrates directed the attention of the French savants to the process of nitrification. Their labors reduced to a system the making of nitric beds, but the maximum production was never more than about 5 kilos of niter per meter cube after the bed had been established for two years.

It was nearly eighty years later that the researches of Schloesing and Müntz, Warington and Winogradsky showed that nitrification was brought about by bacteria, and at the same time afforded a justification and an explanation of the procedure which had been worked out empirically for the niter beds. The discovery of the nitrate of soda deposits in Chile left no place for the old niter beds, but as MM. Müntz and Lainé point out in a very interesting memoir lately presented to the Société d'Encouragement pour l'Industrie Nationale (T. cix., pp. 951-1042. Paris, 1907), the conditions that prevailed at the close of the eigh-

* Nature.

teenth century might recur, and France be again driven to manufacture her war stores of nitrates at home. The authors have therefore been studying in detail the process of nitrification on a large scale to ascertain if the process could be so quickened and intensified as to have any practical value. Starting with sulphate of ammonia as a home product obtainable on a large scale, they worked out the conditions of temperature, concentration, nature of medium, etc., which would result in the maximum formation of nitrates. The most important step they have made is to show that humus, so far from being inhibitive of nitrification, as most organic substances are, is actually favorable, so that peat or turf, which is almost wholly humus, by reason of its great water-absorbing powers and the large surface it offers, becomes the best of all substrata for nitrification, if it is also supplied with a sufficiency of carbonate of lime, and a vigorous growth of the necessary organisms is first established in it.

As a final result of their investigations, MM. Müntz and Lainé show that the optimum production of nitrates is attained when the ammoniacal liquids percolate through successive beds prepared of finely-divided peat mixed with carbonate of lime. It is impossible to begin with a concentrated solution of the sulphate of ammonia, 7.5 grammes per liter being about the optimum when the "nitrière" is in full activity; but after this liquid has been nitrified, successive additions of fresh sulphate of ammonia can be made, and the liquid put through another bed until a concentration of 47 grammes of calcium nitrate per liter is reached, a figure which is still well below the limit of 20 per cent at which nitrification ceases. With such an installation the authors expect a daily formation of 7.5 kilos of nitrate of calcium per meter cube of turf, which represents an extraordinary advance upon the old niter beds.

Of course, the process at present is not within the domain of practical politics; ammoniacal nitrogen has practically the same market value as the nitric nitrogen produced, so that the labor expended and the cost of evaporating the final solution would all be wasted; but, as the authors began by pointing out, the occasion may arise when a country without command of the sea may require to manufacture its own nitrates. Then "nitrières" could be established by a peat bog to convert into nitrates the ammonia which could be distilled out of the peat. The only doubt that occurs to us is what opening the recent electrical methods of making nitrates from atmospheric nitrogen will even then leave for such a process.

# THE BEST KIND OF COAL FOR A FACTORY.*

## SOME THINGS A MANUFACTURER OUGHT TO KNOW.

### BY E. G. BAILEY.

The majority of manufacturers are dependent upon the combustion of coal for the operation of their mills. The man who is responsible for the continuous and economic operation of the plant should know: (*a*) Where he can always get coal when he needs it. (*b*) Where he can get coal of such character and quality that his plant will not be crippled for lack of steam. (*c*) What coal is the most economical for him to burn. (*d*) How to convert a large percentage of the heat energy of the coal into useful work.

(*a*) It is an exceptional circumstance when a manufacturer does not have many kinds of coal offered him at competitive prices. But at times of strikes or delays in transportation he is sometimes compelled to seek coal and pay whatever price is asked. In placing a contract this point should be kept in mind and whenever the difference in price is not too great, preference should be given to the company that is most able to keep you supplied with coal at such exceptional times. If you expect fair treatment from the coal company you must treat it fairly by living up to your part of the contract, whether the price falls or rises during the continuance of the contract.

When plants are at any great distance from the mines it becomes necessary to store a considerable quantity of coal. This involves additional expense, due to the extra handling, value of storage space, and loss of coal both mechanically and chemically. The loss due to oxidation or weathering of coal not only reduces the calorific value of the coal, but as the temperature of the pile rises, the oxidation becomes more rapid until the ignition temperature is reached, and much additional labor and expense is necessary to prevent the burning of the coal and often the destruction of other property. There are many theories as to the cause of spontaneous combustion in coal piles and several remedies have been tried with more or less success. Storing coal under water seems to be the only method of absolute prevention. Sulphur is generally referred to as the cause of spontaneous combustion, but each per cent of sulphur if burned completely and no heat was radiated from the pile during the slow combustion, would raise the temperature of the pile only 200 deg. F. Many cases of spontaneous combustion occur in piles of coal that contain less than one per cent of sulphur, and analyses of coal from heated piles show that only a small percentage of the sulphur has been oxidized. Some heat must be radiated from the pile and a temperature considerably above 200 deg. F. is necessarily reached. Should the sulphur exist in the form of pyrites and both the iron and sulphur oxidize, the heat generated would not be great enough to cause the temperature of the pile to rise as high as 550 to 600 deg., which temperatures have been reached before the coal really ignited. Excessive moisture may play some part in causing spontaneous combustion, but exceptions to this are many. The height to which the coal is piled is generally considered a very important factor, but frequently the hottest part of a pile 20 feet deep is within 3 feet of the surface. In one case a pile of coal 10 feet deep took fire about 6 feet below the surface and in another part of the same pile the coal was 35 feet deep with no signs whatever of heating. Some coals store better than others, the reason for which seems to depend upon the physical structure rather than the chemical composition.

It seems that the rate of circulation of air through a coal pile has more to do with this question than any other condition outside of the character of the coal. The heating is mostly very irregular throughout a pile, as there are usually spots where the temperature is much higher than in the surrounding space. For this reason the usual method of taking temperature measurements in a pile by letting a thermometer down a set of pipes scattered throughout the pile is very unsatisfactory as the hottest spot that will soon cause trouble may be missed entirely. The question, What is the safety limit for the temperature of a coal pile? is frequently asked, and it is rather difficult to answer, for a coal pile may heat up to a pretty high degree, then cool down without being moved. But if there is enough heat generated to raise the temperature of the coal pile to 212 deg. F., the moisture being evaporated at or before this temperature is reached, leaves only the dry coal, which has a comparatively low specific heat, to be heated. The heating takes place much faster and the rate of oxidation also increases with the rise in temperature. The carbon in the coal evidently oxidizes to a considerable extent, as large percentages of carbon dioxide have been found in coal piles at comparatively low temperatures.

(*b*) Many plants are so limited in boiler capacity, have such poor draft, or some kind of grate or stoker, that it is possible for their boiler room force to keep steam with only certain kinds of coal. While this is not an ideal state of affairs, it is a condition that exists in a large percentage of the power plants in this country, and unless a man knows what coal will develop the required boiler horse-power in his plant he may have the costly experience of shutting down a part or all of his mill. There is a great deal of difference in the rate of combustion of different coals. The percentage of volatile matter, coking properties, amount and nature of ash, are the principal factors upon which depends this characteristic in various coals. It is not always the better or higher priced coals that give the best satisfaction under such conditions, for a cheaper coal might give more satisfactory results than are being obtained with the highest priced coal on the market, but the risk of experimenting has seemed too great for the management to consider stepping out of the well-beaten path.

(*c*) All minerals or raw material are bought because they contain some one ingredient or property that may by a certain treatment or operation be enhanced in value or utilized by the manufacturer in such a way as to cause him to make a profit from the principal product of his factory. It is seldom that any mineral or raw material does not contain some impurity or inert matter that may involve additional expense for its riddance or by a certain process may be converted into a by-product and thus become a secondary source of profit. Coal varies more in character and quality than any other mineral produced. In character it is found in all successive stages between lignite and anthracite. Each different kind is more applicable for one purpose than another. In selecting a coal for making illuminating gas, the yield of gas measured in "candle feet" is of primary importance, while the coke and tar are by-products, and sulphur is the impurity that causes additional expense. For making coke the purity, structure, and yield of coke are the properties to be considered, and the gas, tar, and ammonia may be utilized as by-products. In buying steam coal, the amount of heat that may be developed from it is the measure of its value to you. There is no by-product that may be utilized, except that in some cases the sale of ashes might be considered in this connection, but their removal is generally an additional expense. Two coals at the same price and containing the same number of heat units may not be equally desirable. The difference in volatile matter might cause the lower to prove more satisfactory under certain conditions of smoke restriction, while the higher volatile coal would probably be more applicable in a plant with fluctuating load. The amount and nature of ash in regard to the formation of clinker often needs to be considered.

The liability to spontaneous combustion of one coal more than another may make it advisable to pay several cents per ton more for one coal containing no more heat units than the other.

The following table shows the analyses and results of evaporative tests of some of the better coals, together with their price f. o. b. cars at the plant of an inland New England mill. The relative values have been calculated by taking coal A as a basis and determining what will be the cost of the equivalent amount of coal required to produce the same number of heat units as coal A produces for $4.60 per ton. For example, should you buy coal F at $4.40 per ton your coal bill would amount to the same as if you had bought coal A and paid $4.92 per ton for it, but as you can get coal A for $4.60 you would save 32 cents per ton by taking coal A instead of coal F at the given prices.

| Coal. | Moisture. | Volatile. | Fixed Carbon. | Ash. | Sulphur. | B. T. U. | Pounds of Water Evaporated from and at 212° F. | Price F. O. B. Plant. | Relative Cost per Ton with Coal A as Basis. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | By B. T. U. | By Evaporation. |
| A | 1.25 | 17.94 | 73.15 | 7.66 | 2.07 | 14354 | 9.93 | $4.60 | $4.60 | $4.60 |
| B | 1.43 | 17.59 | 71.58 | 9.40 | 1.09 | 14032 | 9.73 | 4.55 | 4.65 | 4.64 |
| C | 1.17 | 30.51 | 61.01 | 7.31 | 0.99 | 14251 | 9.79 | 4.65 | 4.69 | 4.71 |
| D | 1.36 | 16.42 | 71.35 | 10.87 | 1.77 | 13811 | 9.60 | 4.58 | 4.76 | 4.74 |
| E | 1.75 | 19.58 | 71.95 | 6.72 | 0.82 | 14533 | 10.08 | 4.86 | 4.80 | 4.79 |
| F | 3.72 | 21.06 | 66.90 | 8.32 | 1.36 | 12834 | 8.80 | 4.40 | 4.92 | 4.96 |
| G | 1.74 | 31.16 | 53.68 | 13.42 | 2.98 | 12833 | 8.67 | 4.60 | 5.14 | 5.27 |

In this case it appears that neither the best nor the lowest priced coal would be the cheapest to buy.

In this table the coals are arranged in order of cost for equal amounts of heat generated and equal evaporation, but in selecting a coal for any particular plant it might be policy to select a coal that would cost a little more money in order to obtain some particular advantage that a certain coal might have over another. Comparing coals A and B, coal A appears to be better in every way except that it contains about one per cent more sulphur than does coal B. For steam purposes the sulphur is of little importance below two per cent at least, so that coal A would probably be selected on account of its being five cents per ton cheaper on a heat unit basis, and there would also be less ash to handle. In case a plant had limited draft and boiler capacity a coal like C might be selected in preference to B or even A with a difference of nine cents per ton in favor of coal A. Should the prevention of smoke be an item of considerable importance, coal D would probably be purchased at an additional expense of seven cents per ton as compared with coal C. Of the two coals D and E there is a difference of only four cents per ton, and that would scarcely pay for the additional cost of handling ashes, the possibility of not being able to carry the load without the use of more boilers, and other expenses that are greater with a poorer coal.

While coal E is the best all-round coal, it would not pay to purchase it when coal A could be obtained for 20 cents per ton cheaper on a heat unit basis, and 19 cents per ton cheaper on an evaporation basis.

Coals F and G are both much inferior to the others and their purchase would not be considered when any

* Paper read before the National Association of Cotton Manufacturers.

of the other coals were available at the given prices. Judging from the ash and sulphur alone it would seem that coal F would be better than either B or D, but a certain characteristic appears in this coal that makes it different from any of the others. It is "crop" or "red" coal coming from a part of the seam near the outcrop which is saturated with the surface water that has been percolating through it for hundreds of years. The moisture is much higher than in any of the other coals, and it contains a still larger percentage of combined water that is not driven off by the mere drying of the coal. If a man were depending upon the ash determination alone he would never detect that he was receiving an inferior quality of coal; in comparison with coal A he would be paying 20 cents per ton less for the coal, yet he would have to burn so much more of it to develop the same horsepower that he would actually be losing 32 cents per ton, or $16,000 per year on a 50,000-ton contract.

Coal G is high in ash and sulphur and correspondingly low in British thermal units, so that it would be a very expensive fuel to burn at the price quoted, and in comparison with the other coal you would not consider it. Yet there are thousands of tons of it being burned and the manufacturer seems to be willing to pay the price.

In the preceding table the equivalent evaporation in pounds of water from and at 212 deg. F. is given as determined in carefully conducted boiler tests on the same boiler. They represent the average of two or more tests under as nearly identical conditions as it is possible to maintain, thus accounting for the closeness of their comparison with the British thermal unit determination. Duplicate boiler tests on the same coal frequently vary 5 to 10 per cent even though the method of firing and the rate of combustion have changed as little as possible. The chemical analysis and calorimetric determination will represent the value of coal within one per cent, provided the samples are properly taken. The plea for evaporative tests because they are practical is counterbalanced by their failure to burn the coal under equally comparable conditions in two or more cases. A fireman must become accustomed to different coals and find wherein they must be handled differently in the firebox in order to obtain the best evaporation from each. The laboratory tests are generally considered as theoretical and unreliable. But theory and practice always agree when they both represent the facts.

After the most economical coal has been selected, it remains for the manufacturer to see that such coal is delivered. Throughout the year the coal company may send coal of different quality from other mines, or the quality of the coal from the same mine may change, due to impurities encountered in the seam or lack of preparation at the mine. The coal operator may know of the change in quality, as many of them follow up their product by chemical analysis and inspection much more closely than does the purchaser, but it is the manufacturer's place to know what he is getting and prove to the coal company that the coal has changed and that he is not receiving the coal he is entitled to by the contract. The results of an evaporative test mean but little to anyone except the man who conducts them, and apply only to the one plant and set of conditions under which they were made, while the analysis of coal is now on such a standard basis that the results are comparable whether the sample is taken at the mines, *en route*, or at the destination. There are many analyses published and given out by a large number of coal companies that represent selected samples of the coal from certain parts of the seam that are absolutely valueless as representing the quality of coal actually loaded at their tipple. Such a policy is short-sighted and is fortunately disappearing, for the consumer is going to find out for himself when the coal reaches his plant, and the comparison of results is generally to the discredit of the coal company. But the person who has suffered the most from this practice is the coal man who does give representative figures, for he is judged by the consumer as also giving fancy results, and allowance is wrongly made for shrinkage. The present-day tendency is to buy coal on a British thermal unit basis, adjusting the price for the coal delivered in accordance with its quality. The advisability of carrying this into effect depends upon the tonnage, method of delivery, and difficulty in otherwise obtaining a uniform product. The fact that a coal company knows its coal is being systematically analyzed is generally sufficient to insure the delivery of coal of uniform quality.

In addition to knowing what is the most economical coal to buy, the manufacturer must know:

(*d*) How to convert a large percentage of the heat energy of the coal into useful work. The efficiency of a boiler plant depends primarily upon the completeness of combustion of the fuel and completeness of absorption of the generated heat by the water or steam in the economizer, boiler, or superheater. It is impossible to generate into available form all of the heat energy of the coal. Some coal and carbon are lost with the ashes, while combustible gases and carbon in the form of smoke usually escape unburned to a greater or less extent. The loss due to incomplete combustion depends largely upon the design of the grate, furnace, and combustion chamber, as well as the proportionate rate and method of supplying coal and air to the furnace.

There are so many kinds of mechanical stokers, special furnace designs, fuel-saving devices, and smoke preventers on the market that the manufacturer is at a loss to know which one would give the best results in his plant or whether it would pay at all to change from the old hand-fired stationary grate. Many people install a certain appliance because it has given satisfaction in some plant known to them. They do not stop to consider that their conditions may be different; they may have a more fluctuating load; it may not do equally well with the coal they want to burn; or they may not have men of the necessary intelligence or experience in their boiler room to successfully operate the appliance. A mechanical stoker that does very satisfactory work when one kind of coal is being burned may fail when fed with another coal. The fault does not lie in the stoker, but in the judgment of the man who tried to burn a certain coal on it under certain conditions. A man hand-firing a stationary grate also frequently fails to keep steam with one coal when he could with another. It may or may not be the fault of the fireman, but such difficulty is usually due to his unfamiliarity with the coal, and he tries to fire it in the same manner he has been accustomed to firing the coal he has previously used. If two firemen, one having always burned a good coal that formed practically no clinker, and the other a coal which clinkered badly, should both receive the same kind of coal of medium quality, one might fail to keep steam and the other would consider that it was of very good quality. In many cases it would pay to make changes in the boiler plant or add more boilers so that the most economical coal could be burned regardless of its quality, as well as to secure as nearly complete combustion as possible.

The question of smoke prevention must receive more consideration from the manufacturer in the future than it has in the past. While it may not be possible or economical to prevent the last traces of smoke, yet there are many stacks in different parts of the country that issue so little smoke that they are not at all objectionable. In most cases where other than anthracite coal is being burned, the prevention of smoke has been accomplished by means of furnace design and the method of firing.

After combustion has taken place, the heat of the coal appears in the form of sensible heat in the gases leaving the furnace or combustion chamber. The important problem is to cool the gases as much as possible with a minimum of boiler heating surface. In order to accomplish this the heating surface should be kept clean inside and out. Too much emphasis cannot be put on this point. Combustion is more complete with considerable excess air, but this excess air passing through the furnace reduces the temperature of the gases approaching the boiler and the temperature of the escaping gases remains about the same, so that a larger percentage of the developed heat is lost up the stack. This condition might be compared with a steam engine running with low initial pressure and exhausting against a high back pressure. The amount of air excess is regulated by the intensity of draft and condition of the bed of fuel. Few firemen have ever had the opportunity of learning what was the best thickness of fire or intensity of draft under the conditions existing in their boiler plant when burning a certain kind of coal. Many people think the stronger the draft the better, but there is opportunity to save thousands of dollars every year in many plants by merely reducing the draft or better regulation of it. The installation of a damper regulator is not always the remedy, for they often cause more loss than occurred when hand-regulated dampers were used.

The analysis of the flue gases is the best criterion for regulating the conditions of a furnace so as to obtain nearly complete combustion with a minimum of air excess. The perfecting of automatic gas indicators and recorders will do very much toward increasing the boiler room efficiency.

No one kind of boiler or heat-absorbing apparatus will give equal satisfaction in all plants. This depends upon location of plant, kind of water, uniformity of load, kind of coal, etc., and must be determined in each individual case.

It may seem unnecessary to investigate so thoroughly what would be the most economical fuel, how it can best be burned, and how the largest percentage of the heat can be converted into useful work, but the money saved by doing so, even in the smaller plants, amounts to a surprising sum in the course of a year. The manufacturer who is too busy enlarging his mill and increasing his output to give corresponding attention to his boiler room usually regrets the mistake when all his labor is standing idle for lack of power or the coal bill becomes a disproportional percentage of his cost of operation.

## COPPER PLATING.

By FRIEDRICH HARTMANN.

COPPER, as appears from the description of its general properties, is itself one of those metals which oxidize very strongly under the action of moist air, and it is therefore evident that it cannot be used to provide other metals with a protective coating. Metals are usually copper-plated only for the purpose of giving them a more beautiful appearance, or to facilitate the application of other metals which may serve for protection. It is, for example, useful, as was observed in considering the subject of tin-plating, to copper-plate iron articles which are afterward to be tinned.

To give a superficial coating of copper to brass articles, for instance, it is only necessary to wrap them in iron wire and dip them into dilute sulphuric acid; the zinc will dissolve from the surface of the brass while the copper remains undissolved, and the objects will have, in consequence, a light coating of pure copper. To give a durable copper plating to brass, it is immersed for about a minute in a fluid consisting of ten parts of blue vitriol, five of sal ammoniac, and one hundred and fifty parts of water; the objects are then heated, before drying, over a coal fire, until the pure red copper color appears, then rinsed and dried.

There is also another method of copper-plating brass. The brass is first made smooth and bright, which can be done very quickly by immersing it for a few moments in nitric acid; the acid is quickly rinsed off with water, and the objects are heated over a coal fire until they begin to be blackish brown. They are then dipped, while hot, in a solution of zinc chloride, in which the blue vitriol is dissolved, and held for a while in this fluid, which is kept boiling hot while touching them with a piece of zinc. When taken out, rinsed and dried, they will show a very beautiful dull copper color.

To give brass objects the appearance of bronze which contains much copper, they are either laid into a solution of entirely neutral verdigris, or into dilute hydrochloric acid, and left until the desired color appears.

To produce a fine and durable copper plating on zinc, a solution of blue vitriol in water is first prepared, and to this cyanide of potassium solution is added, until the precipitate formed in the beginning is dissolved again on stirring. Finally a fifth part of ammonia solution is added. If the zinc objects are left in this fluid for twenty-four or thirty-six hours, they will appear after this time with a beautiful and durable coating of copper. It is better to use the copper plating fluid somewhat diluted, and to leave the objects in it for some time, as this will give a finer coating.

If iron is immersed in the solution of a copper salt, a coating of metallic copper will at once be deposited upon it. In order, therefore, to give to iron a superficial copper plating, as is useful previous to tin plating, to make the tin adhere more easily, it is only necessary to immerse the objects for a few seconds in a dilute solution of blue vitriol. But the copper coating formed in this way has but a very weak hold on the iron, and a more complicated process must be gone through to produce a durable copper plating.

For such a purpose, in the case of iron or steel, the objects, first made bright, are laid into a fluid composed of one part by volume of hydrochloric acid and three of water, with some blue vitriol also dissolved in it. After a while, concentrated blue vitriol solution is added, and this is done repeatedly, until the copper coating is heavy enough. The objects are then rinsed first in soda solution, then in water and finally polished with chalk and with the polishing iron.

The most durable copper plating is produced by first pickling the iron or steel objects until bright, in dilute sulphuric acid, rinsing, wrapping in zinc wire and immersing in a copper bath of the following composition; 750 grammes (or parts by weight) of Rochelle salt, 400 grammes of solid caustic soda dissolved in 1,000 grammes of water, these ingredients to be mixed with 170 grammes of blue vitriol dissolved in 1,000 grammes of water. The objects must remain in this bath from one to two days, according to the thickness of the copper coating desired.

To copper-plate iron wire, this must first be plated with zinc (galvanized), which is done by diluting hydrochloric acid with ten times its volume of water, putting a zinc plate into the fluid, and laying the iron wire on this. After about two hours a sufficiently heavy layer of zinc will have been deposited on the iron, and the wire is then laid into a solution of blue vitriol, and will be sufficiently well copper-plated after from five to fifteen minutes. Wire copper-plated in this way is, however, greatly inclined to rust, so that the method is not of special value.

The Plating of Metals with Brass or Bronze.—Coatings of brass (which is a mixture of copper and zinc) can be applied to other metals, and such coatings are employed to give the objects the appearance of gold. To change copper—copper wire, for example—superfi-

cially into brass, it is pickled by immersion in nitric acid and boiled in a solution of tartar, with which zinc amalgam (consisting of 1 part of zinc and 12 parts of mercury) has been mixed. On being removed from the fluid the wire appears white, and is then heated so strongly that the mercury evaporates and a layer of brass remains behind on the wire. If this is now passed once through a wire-drawing plate, it will take on the appearance of gold.

Small iron objects, such as nails, are coated with copper by immersion in a mixture of blue vitriol and sulphuric acid, after which they are put into vessels of fire-brick and surrounded by powdered coal and zinc oxide (zinc white), thoroughly mixed; the vessels are closed and heated red hot. The zinc oxide is thereby reduced to zinc, which volatilizes and is alloyed with the copper to brass. Nails can also be coated with brass by zinc plating them by means of dilute hydrochloric acid and zinc, and copper plating with green vitriol solution and heating in powdered coal, and the coatings obtained by these two methods are distinguished by great durability.

To coat iron wire with bronze, it is dipped into dilute hydrochloric acid in which zinc plates have been placed, then passed once through the wire-drawing plate, and put for a few minutes into a fluid composed of solutions of four parts of blue vitriol and one part of tin-salt. By this means there is formed on the wire a copper and tin (bronze) coating of beautiful color.—Translated from "Das Verzinnen, Verzinken."

# A SIMPLE ALTERNATING-CURRENT MOTOR.*

## HOW IT CAN BE BUILT AT HOME.

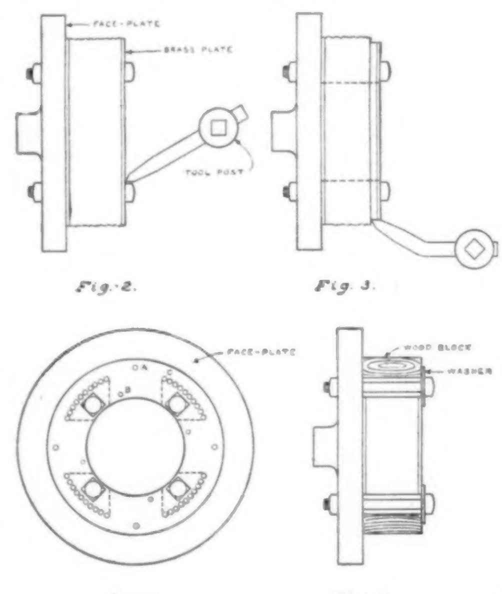
### BY FREDERICK E. WARD, E.E.

A small motor can be constructed by any one having ordinary skill in the use of tools, and having access to a screw-cutting lathe with a swing of nine inches or more, by following the instructions given here.

The motor is of the type known as a "creeping field" induction motor, and is designed to run on a 100- to 120-volt, 60-cycle, single-phase alternating-current circuit, such as is now in widespread use for the lighting of dwellings. Being a four-pole motor, it will run at a speed of something like 1,600 revolutions per minute, and will, if well made, deliver about 1/4 horse-power. This is sufficient to drive either a 16-inch brass fan, a small lathe, a 50-watt dynamo for generating direct current for charging storage batteries, or, in fact, almost any kind of work that can be done by one-man power. It should be noted, however, that a creeping field motor is adapted to run in one direction only; so that when set up for driving a screw-cutting lathe the motor should be belted to a light countershaft having two belts, as is done when steam power is used. For most other cases where reversing has to be done it is sufficient to merely turn the motor around and put the pulley on the other end of its shaft.

A small alternating-current motor is much easier to build than a direct-current motor, for the reason that the armature, or "rotor" as it is called in an A.C. machine, requires no such delicate parts as insulated wire coils, commutator, and brush-rigging. The field magnet, or "stator," offsets much of this advantage, however, as it is impossible to use an iron or steel casting for this part, since the entire magnetic circuit must be built up of thin plates of sheet steel. If a solid casting were used the alternating current would set up wasteful or eddy currents within it, and the motor would be burned up by the energy thus converted into heat. In factories where small motors of this kind are made, the thin sheets for the stator and rotor are punched out by machines built for the purpose. For the amateur, however, the only successful way in which so many irregular-shaped pieces of metal can be made all alike is to first bolt the required number of steel sheets on the face-plate of a lathe, and then bore out the inside and turn off the outside to have the form and dimensions as shown in Fig. 1.

For the stator core about 25 pounds of thin sheet steel are required, cut 7 inches square. This is sold at hardware stores under the somewhat misleading trade names of "Russia iron," "sheet" or "stovepipe iron,"



DETAILS OF FACE-PLATE WORK.

and "roofing tin." The most desirable thickness is about 15/1,000 or 1/64 of an inch, but anything thicker than 25/1,000 will answer the purpose. If roofing tin is selected, the cheaper grades are the most desirable, and better if somewhat rusty. When tightly compressed, the bundle of sheets should measure 1 3/4 inches in thickness or a trifle over.

If the lathe is large enough to swing a piece 11 inches in diameter, the bundle of sheets may be mounted on the face-plate without further trimming; but if a 9- or 10-inch lathe is used, then an inch or so must be clipped from the four corners of each of the sheets. The ease with which the work of boring and turning can be done depends very much on how firmly the sheets are bolted to the face-plate; and if the following method is adopted, the mass will behave almost as if it were a solid block.

Procure about ten pieces of stiff, hard wrapping paper, and two flat pieces of sheet brass not less than 1/4 inch thick, all of them being the same size as the steel plates. Lay the face-plate on the bench, face up, and pile on it first the paper, second one of the brass plates, third the bundle of steel sheets, and finally the remaining brass. Straighten up the pile as neatly as possible, and have the centers of all the pieces coincide as nearly as may be with the center of the face-plate. The whole must be firmly clamped together by means of four wood or metal clamps, to hold the mass while it is being drilled for the four bolts that are to hold it on the face-plate while it is being bored and turned. To mark off the places for these four bolts, first find the true center of the upper brass plate by measuring from the periphery of the face-plate with a pair of dividers or with a rule and square. From this center strike a circle of 2 5/16 inches radius on the brass. When this circle is divided into four equal parts, the points so found will be at the corners of a square which will measure a trifle over 3 1/4 inches on a side. The bolt holes are drilled through these corners, so that the whole mass may be bolted together with machine bolts not less than 3/8 inch in diameter. (See Fig. 2.) At least two of the bolts may be made to pass through the radial slots in the face-plate, but if the latter is provided with *six* such slots it will, of course, be necessary to bore right through the plate in making the other holes. As soon as each hole is drilled put in the bolt for which it was made from the front side, and tighten up the nut. When all have been tightly set up, the clamps may be removed and the face-plate will be ready to be screwed on the lathe spindle.

"Make haste slowly" is one of the secrets of success in working a pile of laminæ in a lathe. Put in the back gears and run the belt on the largest of the cone pulleys, keeping the speed of the work down to thirty revolutions per minute or even less. An ordinary V-shaped threading tool, as shown in Figs. 2 and 3, is one of the best to use. Feed the tool slowly by hand. As each successive plate becomes nearly cut through the tool will catch in the ragged edge and the entire piece to be removed will be quickly torn out. When the bulk of the metal has been thus cut away, the pieces may be bored and turned to the exact dimensions with ordinary tools and slow power feed. Make the bore 3 3/4 inches in diameter, and the outside 6 3/8 inches.

Before unscrewing the face-plate from the lathe, take a light cut off the face of the brass plate so as to make the part of it lying outside of the bolt heads

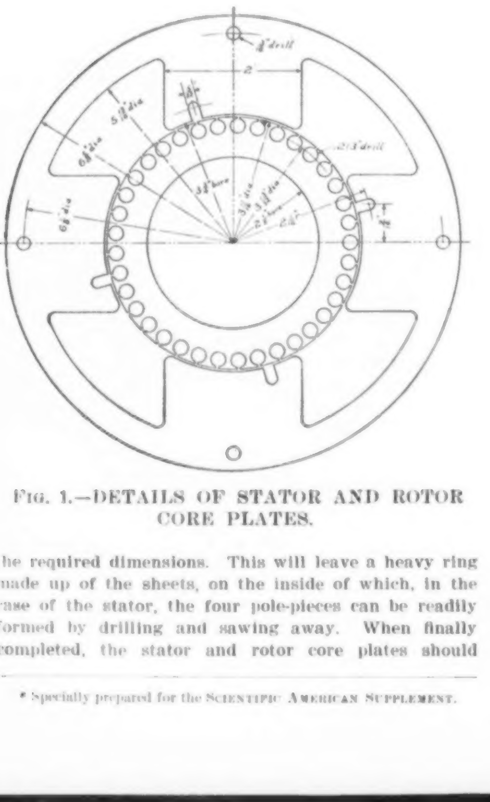


FIG. 1.—DETAILS OF STATOR AND ROTOR CORE PLATES.

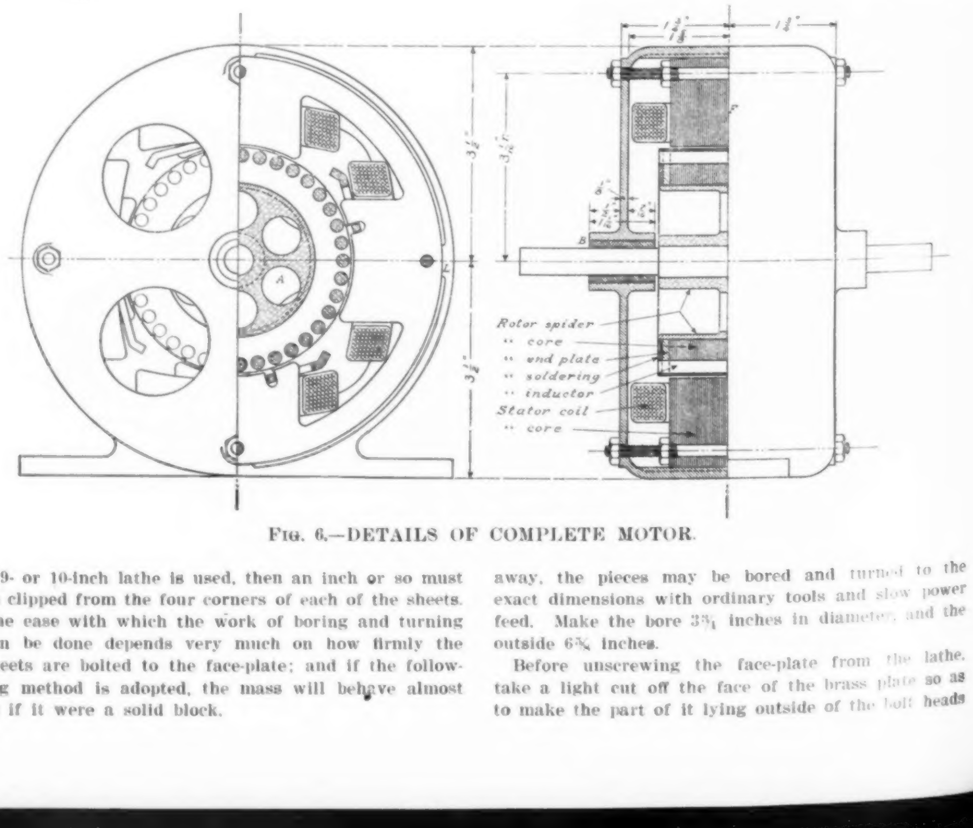


FIG. 6.—DETAILS OF COMPLETE MOTOR.

the required dimensions. This will leave a heavy ring made up of the sheets, on the inside of which, in the case of the stator, the four pole-pieces can be readily formed by drilling and sawing away. When finally completed, the stator and rotor core plates should

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

perfectly true. By placing a sharp pointed tool in the carriage it will then be easy to mark off two circles on the brass, the one being 6¼ inches in diameter and the other 5⅝ inches. These circles will form accurate guides for laying out the permanent bolt holes and the pole pieces, in accordance with the drawing in Fig. 1.

Divide the outer circle into four equal parts, choosing points midway between the bolt heads. If this is done, the removal of the metal between the pole pieces will take away also the old bolt holes, which form no part of the finished core plates. Mark out the outline of the pole pieces on the surface of the brass, and drill all necessary holes before removing the laminæ from the face-plate. As shown in Fig. 4, there are to be four 3/16-inch holes, *A*, for the permanent bolts, four 5/32-inch holes, *B*, to form the bottoms of the slots in the pole faces, and four circular arcs, *C*, made by drilling 3/16-inch holes as closely together as can be done without danger of the drill breaking through from one hole to the next. These last holes will have their centers all on the circle 5⅝ inches previously marked on the brass. It is to be noted that the four holes, *A*, must pass entirely through the second brass plate, but the others need be only deep enough to pass through the steel plates.

When all the holes are drilled, the laminæ will be ready for removal from the face-plate. This can be best done by taking out at first only three of the bolts, after which the bundle of plates may be swung around on the fourth, to permit of the insertion of some of the 3/16-inch bolts. This prevents the springing apart of the plates and avoids the danger of a mix-up. The laminæ, now tightly clamped between the brass plates, must next be held in a vise while the eight cuts indicated in Fig. 4 by dotted lines and the four small slots in the pole faces are made with a hacksaw. The pieces containing the original large bolt holes can then be easily removed, thus leaving the stator plates finished except for roughness, which must be carefully removed with a file. Finally the brass plates may be removed and thrown aside. The operations in the lathe have made a very intimate contact between successive laminæ, so that as far as being an electrical conductor is concerned the stator might now almost as well have been cut out of a solid block. It is very well worth while, therefore, to take apart the laminæ, remove the burrs from each one separately with a fine file, wash them in a pan of benzine to remove oil and loose filings, and finally to give each plate a coat of very thin shellac on one side only before reassembling. It is quite important that the plates be not mixed up during these cleaning operations, as the inevitable irregularities in the form of the different poles and in the location of the bolt holes makes it impossible to reassemble the plates in any other than their proper positions. To avoid this mixing pass a stout string about four feet long through one of the bolt holes and tie a big knot at each end. The plates may then be handled separately, and then be finally put back as they were at first. The finished core must be exactly 1⅞ inches thick.

The work of making the rotor core plates is much

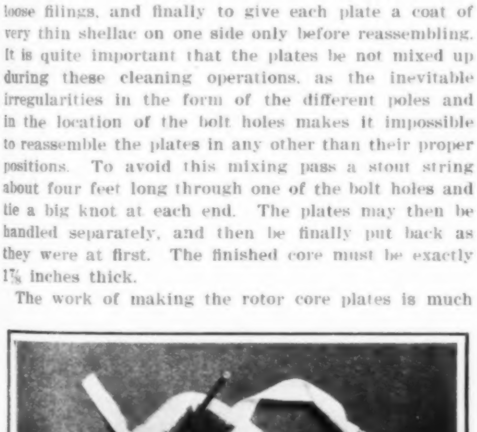
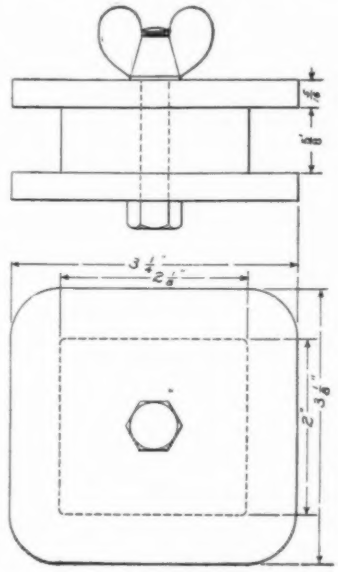


Fig. 9.—COIL WINDING FORM AND PARTLY TAPED COIL.

easier than that of the stator, so only a brief description is necessary.

The material required is about 8½ pounds of sheet steel (similar to that used in the stator) cut 4 inches square, and two copper plates of the same size and ⅛ inch thick. These copper plates are not used merely to make the work of clamping and turning easy, as in the case of the stator, but are to be left at each end of the finished core. If suitable copper plates cannot be obtained, some ¼-inch brass may be substituted. Protect the face-plate with sheets of paper, as before, and bolt on the metal plates with four ⅜-inch bolts. Strike a circle 2 inches in diameter on the upper copper plate, and divide this into four equal parts to find the plate for the bolts. On large lathes the hub of the face-plate will be in the way. In this case screw the bolts into tapped holes made for them



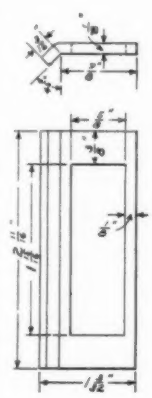


Fig. 5. Fig. 6.

COIL WINDING FORM AND COTTON DAMPER.

either in the face-plate itself or in a heavy, flat metal plate bolted on it.

When the material has been fastened, turn off the outside smoothly to a diameter of 3 11/16 inches. Mark off on the top copper plate a circle having a diameter of 3 13/32 inches and divide up this circle accurately into 37 equal parts, and mark the points so found with a center punch. The correct spacing can be found only by repeatedly "stepping off" around the circle with a pair of dividers, trying different distances between their points until it comes out just right.

It may appear at first sight as if 37 were an unnecessarily difficult number of holes to space off, and that 36 might just as well be substituted, but this is not true. It has been found by experiment that the number of slots should be an odd one. One of the reasons for this will be self-evident if one considers what would happen if the rotor were provided with only *four* such slots, of somewhat larger size, or, to go to an extreme, if an iron cross were to be substituted for the rotor. When the arms of this cross came opposite the four polar projections of the stator they would be very firmly gripped by the magnetic flux, and it would take considerable force to twist the cross out of the magnetic path. After being twisted far enough, however, to become released from the attraction of the poles, the cross would move forward with a jerk to the next favorable position. In a four-pole motor, then, the rotor must not have a number of slots divisible by four, or it will, to a less extent, be found to turn with little jerks that result in vibration and noise when the motor is running, in addition to interfering with its starting.

Drill the 37 holes for the slots with a No. 3 drill, which is 0.213 of an inch in diameter, and make sure that they are deep enough to pass clear through the second copper plate. After the holes are finished it will be necessary to clamp the laminæ to the face-plate so that the four bolts in the middle may be removed to permit of the inside being bored out. One way to do the clamping is to pass six or eight 3/16-inch bolts through as many of the 37 slot holes, but the method shown in Fig. 5 is better. Four ⅜-inch bolts applied as shown will grip the laminæ quite firmly. Bore out the inside smoothly to a diameter of 2½ inches, and before removing the laminæ from the face-plate fit three or four wood sticks in the small holes to keep the bundle of laminæ from falling apart. The final operation is to put the plates in a vise and with a thin hacksaw cut through the little bridge of metal that separates each of the 37 holes from the outside, when the plates will appear as in Fig. 1. The saw-cuts ought not to be more than 1/32 inch wide. If the saw cuts wider than this, it is well to grind off some of the "set" by holding the blade flat against a grindstone.

Clean and shellac the rotor core plates as was done with those of the stator, and guard against mixing them. Before separating the plates file a well-defined groove inside the central hole, so as to make a slight notch in each plate to serve as a mark, and then pass a stout string through the hole and tie the ends together.

In Fig. 6 are shown details of the rotor shaft, spider, and "winding." The material required for the shaft is a piece of cold-rolled steel 9/16 inch in diameter and 7 inches long. This should be held in the lathe chuck while truing up each of the ends and drilling the centers in them, after which it may be supported between the lathe centers and finished all over. Make the central portion ½ inch in diameter and 2¼ inches long, and the bearing portions 7/16 inch in diameter. The latter, after being turned and filed as smoothly as possible, should be given a polish with a piece of very fine emery paper wet with machine oil.

The best material for the spider is a brass casting, for which it is not difficult to make a wood pattern by turning off a piece of white pine in the lathe. A very good substitute for the brass, however, can be made of Babbitt metal, or of ordinary plumbers' solder, which can be cast at home in a sand or plaster of Paris mold, or even in a wooden one. The rough spider casting should be drilled with a 31/64-inch drill, reamed to ½ inch to fit the shaft, and secured to the latter by pinning with a small steel pin. If one of the suggested methods of making the casting at home be adopted, there is no reason why the spider may not be cast right on the shaft itself, thereby saving the trouble of fitting it to the latter afterward. The cylindrical surface of the spider must be turned in the lathe to a length of 2¼ inches and a diameter of 2½ inches, or rather, to such a diameter as will permit of the rotor plates being put on easily without being loose enough to shake. On the inside the spider should be finished all over, to make it as light as possible and to keep it balanced. The rim needs to be about 3/32 inch thick, and the arms and the hub about 3/16 inch thick. The six holes shown at *A* in Fig. 6 are not merely for ornament, but are to allow of air passing through the machine for ventilation.

Assemble the rotor core plates on the spider with one of the copper or brass plates at each end. Use only enough of the steel plates to make a length of 1⅞ inches, which will make the length when the end plates are in place just 2⅛ inches long, and leave about 1/16 inch of the spider projecting at each end. For the "inductors" to go in the slots, procure 7½ feet of No. 4 copper wire, which is 0.20431 inch in diameter, and after straightening it out saw off thirty-seven pieces each 2¼ inches long. Clean these carefully by scraping each of the ends for about ¼ inch with a knife. The middle portions may be left as they are, but if the best results are desired, it is worth while to glue on a wrapping of thin paper to insulate the inductors from too much contact inside the slots. Insert the wires in the slots and rivet all the projecting ends by tapping lightly with a hammer until each one is expanded enough to prevent its dropping out. The inductors are next to be soldered to the end plates, to make good electrical contact all around. To do this, stand the rotor up on end, and apply some good quality soldering salts or paste to the riveted heads, end plates, and spider. Use a *hot* soldering copper, and apply the solder very generously so as to bury all the rivet heads out of sight. When both ends have been thus treated, place in the lathe again and true up the soldered rings by turning off the solder until the copper inductors begin to show. This will complete the

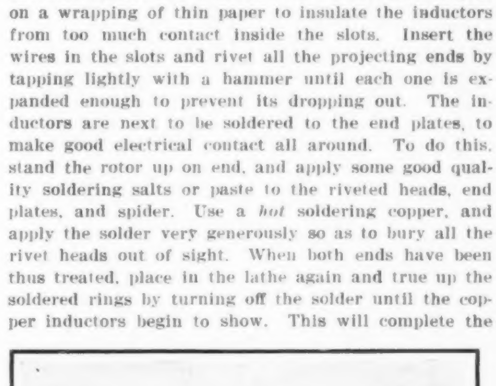


Fig. 10.—ASSEMBLING THE PARTS.

rotor except for balancing. Take two smooth metal rods of any convenient size, and support them about 4 inches apart on the upper edges of an empty box, as if to form a miniature pair of parallel bars. Have them as nearly level as possible, and place the rotor shaft with one end on each bar. If the rotor is out of balance it will, of course, roll over and stop with the lighter side up. Make a mark at this place, and apply

a little solder to the inside of the spider as near to the arms as possible. Increase or reduce the weight as required until the rotor will lie indifferently in any position in which it may be placed on the rods. This type of rotor is known as the "squirrel cage."

In Fig. 6 there are also shown some details of a suitable external casing for the motor. This is intended to hold the bearings and the stator plates in a fixed relation to each other, and at the same time to protect the delicate stator coils from accidental injury. It is to be cast in two halves exactly alike, so that both "shields" may be made from the same pattern. Brass castings are the easiest to finish in the lathe, but iron is much cheaper. In the selection of material, and in the arrangement of the details of the casing and bearings, the amateur is advised to use his own judgment and skill, provided that the following points are observed. The rotor must be supported in the exact center of the stator field, so that the air-gap under each of the four poles will be uniform, or 1/32 inch all around. This desired result will be secured as a matter of course, if the seat for the bearing *B*, Fig. 6, the four internal lugs *L*, and the face *F* be all finished in the lathe at one chucking of the casting. The four bolts passing through the stator plates must be long enough to pass also through the end shields, to clamp the whole together as shown. The bearings may be of either brass or Babbitt metal, and the rotor shaft should turn freely in them without being loose enough to shake. Allow sufficient room between the two bearings so that the shaft has an "end play" of nearly ¼ inch, and provide oil cups of some kind to furnish plenty of lubrication. In the end shields there must be several holes to permit air to circulate through the motor and help to keep it cool. If the lathe on which the shields are to be finished is not too small, it is a good plan to have suitable feet cast on them, so that the finished motor may be conveniently bolted fast in the place where it is to be used.

All parts of the motor have now been described, except the winding for the stator, which consists of four copper "dampers" and four coils of wire. The copper dampers are shown in detail in Fig. 8. Each one can be cut from a solid piece of copper sheet ⅛ inch thick, or they may be built up of several thinner pieces having the same total thickness. If the latter method be adopted, the small pieces should be soldered together after they are finished, so that they can be handled as single units.

Figs. 7 and 9 show the winding form for making the stator coils. This consists of three blocks of wood held together by a bolt and revolved in the lathe by gripping the bolt head in the chuck. The central block, measuring ⅝ by 2 by 2¼ inches, is best made of a piece of hard wood, such as maple or mahogany, and it must be quite accurate in each of its three dimensions, since these fix all of the dimensions of the coils. The four corners of the block must be very slightly rounded, to avoid the difficulty of having to bend the first turns of wire around square corners. About two pounds of No. 21 single cotton-covered magnet wire is required for the four coils. Each coil is to have 165 turns, put on in close, even layers. The number of turns is so important that it is not well to trust to the mind to keep tally while winding. Set the gears to feed at some convenient rate, say ten threads per inch, and run the tool carriage to the extreme right-hand end of the bed and make a chalk mark on the bed at that position. Then, when the winding is started, throw in the screw feed, and the movement of the carriage to the left of the chalk mark will count the turns automatically, for when the carriage has traveled 16½ inches, as measured by a foot rule, the spindle will have made the required number of turns. Before beginning the winding, it is necessary to provide means for holding the turns of the coil together so that the blocks may be afterward removed without any danger of the coil coming apart. For this purpose, nothing is better than four strips of cotton cloth about half an inch wide placed crosswise in the space where the wire is to be wound. These may be readily held in place by the first turn of wire, or, better still, by a strip of canvas or tough paper cut ¾ inch wide, wrapped once around the form, and glued to itself like a cigar band. Do not attempt to wind the coils by power, but turn the lathe head over a little at a time by hand, so that the wire can be laid on in closely-fitting, smooth layers. Start the winding near the middle of one of the longer (2¼-inch) sides, and have it end near the same place. It is well to paint the inner end, or terminal, black for the purpose of easy identification later on. After putting the required number of turns on a coil, tie the ends of each of the four pieces of cloth together and remove the blocks.

Fig. 9 shows the method of applying a final covering of tape for protection and insulation. Very thin cotton tape about ½ inch wide is suitable, and it should be lapped on itself about half way in the winding, so that the coil is really protected by two layers. As the taping progresses, the temporary ties may be removed, but the inner band of canvas or tough paper is to be left there as shown. Where the inner lead or terminal comes out across the other layers of wire a piece of paper about ½ inch square should be slipped in to guard against possible short-circuits.

The final assembly is next in order. (See Fig. 10.) The stator plates, in addition to being held together by their four bolts, should be tied with string, as shown. The coils are to be placed on the poles all in the same position, i. e., all of the faces which were next to the lathe head during the winding must be turned either toward the rotor or away from it. Do not force the coils over sharp corners on the poles and run the risk of cutting through the insulation. If the coils do not go on easily, file the corners of the poles round and smooth. The coils and the dampers, when once in place as shown, are most conveniently held in position by bending outward the first lamina on each side of the pole tips, which holds them on as if they were riveted there.

The four coils must be connected in series so as to make the poles alternately positive and negative. One way to do this is as follows: Beginning at any given point, connect the inner end of coil No. 1 to the inner end of coil No. 2. Next connect the outer end of coil No. 2 to the outer end of coil No. 3, and finally connect the inner end of No. 3 to the inner end of No. 4. This will leave free the outer ends of coils No. 1 and No. 4. If the coils are not wound all in the same direction, or are not assembled at all in the same position relative to their respective poles, or the inner and outer leads become confused, then the polarity of the poles will not come out right. To make sure on this point connect the two free ends of the winding to a battery of one or more cells, and present a pocket compass to each of the pole faces in succession. They must show alternately north and south all the way around. In case they do not, some mistake has been made, and this can be easily corrected by exchanging the connections of any coil that shows up wrong. When everything is right, it is worth while to solder the connections and cover them with tape for insulation. Do not apply alternating current to the coils unless the rotor is in its place, properly mounted in its bearings, *and left free to turn*. If this caution is not observed, the coils will be soon burned up, as their resistance alone is not sufficient to prevent their taking too much current from the line.

When assembling the stator in the casing, see that no part of the winding or its connections is pinched or grounded. If any connections lie against the frame, slide pieces of tape under them and glue them fast. Perfect insulation is much more necessary in alternating-current magnets than in direct current. A short circuit between a few of the turns of a coil does no particular harm on direct current, but in the case of alternating current tremendous currents are set up in the short-circuited turns and the entire coil is soon burned up.

The two leads or terminals to the winding may be attached to two pieces of rubber-covered flexible cable brought out through holes in the casing for the purpose of connecting to the alternating-current mains. A much neater way, however, is to attach two small binding posts to the casing, from which they can be insulated with fiber thimbles and washers. No pulley has been shown in the drawings, as the form and dimensions of this will depend on the particular kind of work the motor is expected to do. For ordinary service a pulley of about 2 inches in diameter by 1¼ inches face will probably give the most satisfaction.

No starting box is required for this type of motor. An ordinary socket plug and lamp cord is all that is needed. The rotor, on account of the unbalanced pull exerted by the four dampers on the poles, will start to revolve as soon as the current is turned on, unless it is stuck in its bearings or stalled by an overload.

## THE MEANING OF MILLIONS.

By STANLEY C. BAILEY, A.M.I.C.E., F.G.S.

THIS is the age of millions and millionaires. A few centuries ago people thought in hundreds of thousands, but now one thinks in millions. If one studies political economy, finance, astronomy, the atomic theory, the age of the earth, the vibrations of heat-waves, bacteriology, or even the water supply of towns, one must think in millions, for each generation of mankind must be trained to think on a higher scale than the preceding generation, in order to make progress.

If the national expenditure, taxes, and rates continue to increase annually in the future as they have done in the past, the people of future generations will think in billions, or in millions of millions.

In the United States of America and in France people already speak of billions; but a billion in those countries means a thousand millions.

One million persons collected together into a crowd, with an allowance of 3 square feet per person, would cover an area of 68.8 acres—say, 70 acres—or could be contained in a square having sides 577.6 yards long; or, if one allows 18 inches per person, standing shoulder to shoulder, one million people would extend a distance of 284.1 miles, or from London to Alnwick.

The population of the County of London amounts to 6,549,000, and allowing 18 inches per person, standing shoulder to shoulder, it would form a human wall 1,860 miles long; or the whole population could be placed on an area of 0.7 square mile, or on a square having sides of 0.84 of a mile.

New York has a population of 3,437,000, which would cover an area of 0.37 of a square mile, which is equivalent to a square having sides 0.60 of a mile long.

Paris contains 2,714,000 persons, who could be accommodated comfortably on 0.29 of a square mile, or 0.54 by 0.54 of a mile; and the people of Berlin number 2,040,000 souls, who would cover an area of 0.22 of a square mile, and could be contained in a square having sides 0.47 of a mile in length.

The population of the United Kingdom consists of about 48,220,000 persons, and if an area of 3 square feet be allowed for each person to stand on, this great crowd could be accommodated on an area of 4.62 square miles, equal to a square of 2.15 by 2.15 miles; or, if standing shoulder to shoulder would form a human wall 12,280 miles in length, which would extend halfway round the earth at the equator.

One million cubic yards of excavation is equivalent to a cube having sides 100 yards long; or it may be represented by a bank of earth measuring 1 yard square and 568.2 miles in length.

The excavation in the construction of the Manchester Ship Canal amounted to 54 millions of cubic yards, of which 12 millions consisted of red sandstone rock. The total of 54 millions could be depicted by a wall of material 1 yard square and 30,683 miles in length; as the circumference of the earth at the equator is about 24,884 miles, this wall of excavated material would be sufficient to form a girdle round the world; or it might be represented by a cube of material having sides 378 yards long.

One million tons of rock (allowing 14 cubic feet to the ton) can be illustrated by a cube having sides about 241 feet in length.

In the United States the coal raised per annum totals 350,821,000 tons, which are equal to a cube having sides 714 yards long; and in Germany the quantity raised is 119,349,000 tons, equivalent to a cube with sides 231 yards in length.

One million building bricks, if piled carefully together so as to form a cube, could be contained in one whose sides were 39.8 feet, or, say, 40 feet long, allowing 16 bricks to the cubic foot, laid without mortar, or a million bricks can be depicted by a wall 6 feet high, 9 inches thick, and 2.6 miles long.

In connection with the study of astronomy, it is difficult to realize the meaning of millions of miles, but some idea may be gathered from the time that would be taken by an express train, or the shot from a cannon, to cover celestial spaces.

The distance of the earth from the sun is about 92,000,000 miles, and light traveling at the rate of 186,700 miles per second *in vacuo*, traverses this distance in 8¼ minutes; but a railway train, going at a speed of 60 miles per hour, would take 175 years to reach the sun.

The circumference of the ellipse forming the orbit of the earth round the sun is about 577,760,000 miles in length, and the earth covers this distance in 365¼ days, traveling at the rate 65,910 miles an hour, or 1,098 miles per minute, or nearly 1,100 times as fast as a train going at 1 mile per minute. Therefore, a train traveling at this speed would require nearly 1,100 years to accomplish the journey round the earth's orbit.

The velocity of a rifle bullet is about 2,130 feet per second, or 24.2 miles per minute, and that of the projectile weighing 330 pounds, from a quick-firing 9-inch gun, is about 3,000 feet per second, or 34 miles per minute, so that the velocity of the earth is 32.3 times as fast as the latter.

A million gallons of water, weighing 10 pounds per gallon, is equivalent to 4,464.28 tons, and, allowing 36 cubic feet to the ton, this will be equal to a cube of water having sides 54.4 feet in length, or to a reservoir 126.7 feet square and 10 feet deep.

The quantity of water used annually for fires in the County of London amounts to 14,000,000 gallons, equivalent to 62,500 tons. Of this amount, one-third is drawn direct from rivers, canals, and docks, and the remainder from the water mains; the total of 14,000,000 is equal to a cube having sides 131 feet square.

The total amount of water used annually in the County of London for all purposes is 217,567,000 gallons, equal in bulk to a cube having sides nearly 327 feet long, or to a reservoir 622 yards square and 10 feet deep.

The amount of liquor consumed annually in the United Kingdom is as follows: wine equal to 15,281,000 gallons, represented in volume by a cube having sides 135 feet long; beer, equal to 1,270,828,000 gallons, equivalent to a cube with sides 588 feet in length; and spirits, equal to 44,078,000 gallons, which would form a cube with sides 192 feet square.

One million blood corpuscles (which are each about 1/3200 inch in diameter), if laid in a row, touching one another, would cover a distance of 26 feet, and

1,000,000 bacteria (which are about 1/5000 inch in length and 1/25000 inch in diameter), if laid lengthwise, end to end, would extend to a distance of 16.66 feet; but, if laid side by side, they would be 3.33 feet long.

A gramme of street mud, which is equivalent to a small cube of earth having sides one-quarter inch in length, contains about 78,000,000 bacteria, which, if placed in a line, side by side, would cover a length of 259.74 feet, and a gramme of earth from a cultivated field will contain about 11,000,000 bacteria, which, if laid side by side, would extend a distance of 36.60 feet.

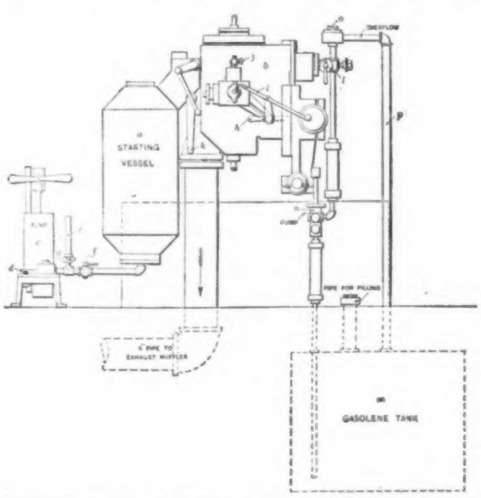
In the Alpine mountains, no bacteria were found in 10,000,000 cubic centimeters of air, which is equivalent in size to a cube of 7 feet sides; but in the air of the streets of Paris 55,000 were found in the same volume of air; while, in the rain-water in Paris, 33,800,000 bacteria were found in a cube having sides 7 feet in length. This is equivalent to about 57 bacteria to 1 cubic inch.—English Mechanic and World of Science.

# STARTING GASOLINE ENGINES.*

## THE AUTOMATIC STARTING DEVICE.

### BY WALTER IRVING.

SMALL gas and gasoline engines may readily be started by turning the flywheel by hand, if the compression is reduced temporarily by opening a small relief cock, or by holding the exhaust valve open during part of the compression stroke. Large engines, after once being put in operation, usually are subsequently started by air compressed during the running of the engine by an air pump directly attached to or driven by the engine. The compressed air is stored in a tank until it is needed after the next succeeding shutdown, when it is admitted into the engine cylinder through a special valve whose operation is controlled by a sliding cam on the 2 to 1 shaft. During the first part of both suction and expansion strokes this valve admits compressed air to the cylinder, while another special cam holds the exhaust valve open during what otherwise would be the compression stroke. When the flywheel has attained sufficient momentum to establish the engine's regular cycle of operations the special cams are shifted out of action and the combustible mixture is admitted to the cylinder and exploded in the usual manner. As a rule, compressed air starters are applied to but one cylinder of a multicylinder engine, the other cylinders taking up their work after the engine has been run a few revolutions on compressed air.




DEVICE FOR STARTING GASOLINE ENGINES WITH A COMPRESSED CHARGE OF THE EXPLOSIVE MIXTURE.

The accompanying engraving shows a starter as applied to an Otto gasoline engine. It consists of a reservoir or starting vessel *a*, connected between the engine *b* and a hand pump *c*. A small quantity of gasoline is poured into the starting pump *c*, through the plug *d*, so that when the pump is operated a mixture of fuel and air passes through the reservoir *a* to the engine cylinder. Before attempting to ignite this mixture in the engine cylinder, it is customary to test it in the testing tube *e*. The cock *f*, between the hand pump *c* and the reservoir *a*, is closed, and the cock *g* at the foot of the testing tube *e* is opened; the upper end of the testing tube is covered with the hand and a few strokes are given to the pump to fill the tube with the mixture; then the cock *g* is closed, the hand removed from the mouth of the testing tube and the mixture quickly lighted with a burning candle or match. If the mixture is properly proportioned it will burn rapidly, giving a fairly sharp report as it burns down the tube, but if it burns slowly, giving a weak report, the mixture is not properly proportioned. The proportions of the mixture of air and gasoline may be changed by adjusting a brass set screw in the top of the starting pump barrel.

Having made the necessary adjustments to secure a good combustible mixture, the engine may be prepared for starting by turning the flywheel until the crank is in its starting position, slightly above the inner dead center, and with the piston at the beginning of the expansion stroke. To facilitate starting, the time of ignition is retarded by turning the handle *h*, so as to lower the igniter blade *i*. The cylinder relief cock *j* is opened, and by raising the hand lever *k* the starting valve between the reservoir *a* and the engine cylinder is also opened. With the cock *f* open and the cock *g* closed, about ten strokes are given to the hand pump to force into the cylinder enough of the mixture to drive out through the relief cock *j* any air or dead gases. The cock *j* is then closed, and after giving ten more strokes to the pump, the valve controlling the passage between the reservoir *a* and the engine cylinder is closed. The pressure within the reservoir is then increased by giving about twenty strokes to the pump, the lever arm of which is lengthened so as to increase its leverage.

When the switch of the igniting circuit is closed and the gasoline fuel valve *l* opened, the engine is ready for starting. Opening the valve operated by the lever *k* allows the high-pressure mixture to rush from the reservoir *a* into the cylinder, forcing the piston outward until it reaches the point at which ignition takes place, and the explosion produces a powerful impulse which imparts to the flywheel sufficient momentum to carry it over the next compression stroke. Immediately after the first explosion, the valve between the reservoir and the cylinder is closed by pushing down the lever *k*, so that the succeeding charge is drawn in, compressed and exploded in the regular way, and as the speed of the engine increases the time of ignition is advanced by turning the handle *h* so as to raise the igniter blade *i* until it occupies its normal position.

The required supply of gasoline is pumped from the tank *m* by a pump *n*, which is driven by an eccentric on the cam shaft and which lifts the gasoline to the cup *o*. From this cup the liquid flows to the gasoline inlet valve or spray nozzle at *l*, and the overflow returns through the pipe *p* to the underground supply tank *m* beneath the engine room floor.

* The Iron Age.

## A NEW IDEA FOR AN INTERNAL-COMBUSTION ENGINE.

AN ingenious idea in the way of gas-engine design is embodied in the class of engine indicated by the accompanying illustrations. This type has been patented in England by H. Campbell, of Dumbarton, N. B., and was recently described in The Mechanical Engineer, of Manchester and London.

Fig. 1 is a sectional elevation of the cylinder of a single-acting engine, and Fig. 2 the cylinder of a double-acting engine, as they would be constructed in accordance with Mr. Campbell's patent. In the single-acting engine, *C* is an exhaust port fitted with a mechanically actuated valve *D*, and *E* is an admission port, located approximately midway of the stroke of the piston and provided with an admission valve *F*, which is closed by a spring *G*; *H* is a passage which communicates with a supply of mixture under pressure. In the illustration the piston *B* is shown in its bottom position, the top position being indicated in dotted lines, and it should be noted that the piston is sufficiently long to cover the admission port *E* when in its top position. In action, with the piston beginning to rise on a compression stroke, the exhaust valve *D* is held open until the cylinder has received a charge of mixture which will flow in past the admission valve *F*, the pressure in the supply passage *H* being sufficient to overcome the reduced pressure in the cylinder of the previously expanded charge and the resistance offered by the admission valve. The exhaust valve *D* is mechanically closed at an early period in the compression stroke of the piston, and the incoming charge is cut off by the automatic inlet valve *F* when the pressure within the cylinder is nearly in equilibrium with the pressure in the supply passage *H*. The charge is then compressed by the rising piston and subsequently ignited to produce the power stroke. When the power stroke is nearly completed, the exhaust valve *D* is opened to release the pressure in the cylinder, and when it has fallen below the pressure of supply the automatic valve *F* opens and a new charge flows into the cylinder, the charge being completed after the exhaust valve is closed.

In conjunction with this cycle of operations it will

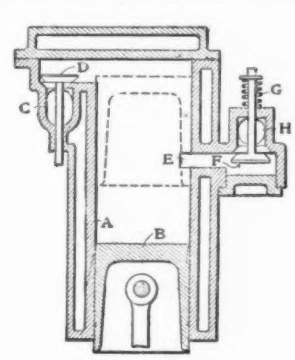



FIG. 1.

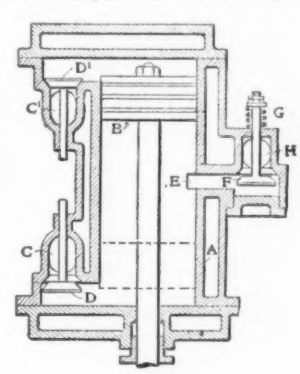



FIG. 2.

be noted that as the port *E* is situated at a distance above the head of the piston when it is down, during the compression stroke a portion of the charge, after partial compression has taken place, will be entrapped in the valve chamber and port opening *E* as the piston advances and remain trapped until the piston again passes the opening on its return or power stroke, when the entrapped charge will be ignited as it becomes exposed to the live charge and produce a supplementary power effort at a stage when the connecting rod is at effective angle with the crank.

Referring to Fig. 2, in which the cylinder of a double-acting engine is illustrated, *C* and *C'* are end exhaust ports fitted with mechanically actuated valves *D D'*, and *E* is the admission port, located approximately midway of the piston travel, as before. The port *E* is fitted with an automatic inlet valve *F*, and *H* is a passage which communicates with a supply of mixture under pressure, as in the previous case. In this form of construction, a comparatively short piston is employed. In action, with the piston in the position shown and beginning to descend on a compression stroke in the lower end of the cylinder, the exhaust valve *D* is held open until the lower end of cylinder has received a charge of mixture which will flow in past the valve *F* as in the cycle of the single-acting engine already described. The exhaust valve *D* closes in the initial movement of the piston, after which the charge will be compressed, and in the advance of the piston the admission port *E* will be brought into communication with the upper part of the cylinder where a power stroke is in progress. With this difference of operation the cycle of action is similar to that in the single-acting engine. The adjunct, however, differs in this case from that in the cycle of the single-acting engine, in that when the port or opening *E* is constructed to receive a portion of the charge in compression the entrapped charge is ignited during the same stroke by the live charge on the opposite side of the piston as the piston passes and uncovers the port.

# PROTECTING VINES OR FRUIT TREES.

## AN AUTOMATIC DEVICE USED IN FRANCE.

### BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

A new automatic device has been brought out in France for the protection of vines, fruit trees, etc., from the action of frost and also from hail storms. All plants, and especially vines, suffer from these causes. In France, where the vines bear a product of considerable value, the loss becomes all the more important. The inventor of the present system, M. Becker-Bertrand, is an inhabitant of Rheims, in the center of the champagne district of the country, and he has made a number of successful applications of his invention in this extensive vine region.

There are other methods for protecting plants against hail or frost, but we do not hear that any of them have met with success on a practical scale. This is no doubt due to the fact that they are applied by hand. What is needed is to be able to use covering cloths or shelters, straw matting covering, and to apply it quickly over the plants or beds from a distance. On a large tract, this distance may be considerable, hence the need of a proper automatic device.

M. Becker-Bertrand's device for this purpose is simple and effective. As regards the character of the shelters which are used, these will be easily noted by referring to the accompanying views, which show various forms of shelters grouped together. The canvas shelters are made of pieces which slide by means of rings upon a set of wires, so as to form a roof and two sides around the vines or fruit-tree rows. The rings are operated by a set of wires and levers, the whole device being worked by a wire connected with the central post, where a counterweight is released at the proper time and pulls upon the main wire. Another kind of shelter consists in a straw matting which is placed vertically when not in use. A set of levers brings it into the horizontal position, as will be seen to the left of the figure, in order to make a roof over the plants. In the same way, taking the case of vines running upon a wall, or fruit trees trained against a wall, a simple curtain mounted on a roller can be let down at once after the manner of a roller shade, and give a good protection. The form of shelter can be varied to suit the circumstances.

FIG. 1.—ON THE LEFT ARE STRAW MATTING COVERINGS; ON THE RIGHT CANVAS SCREENS. AGAINST THE WALL "ROLLER BLIND" SCREENS ARE AFFIXED. THIS SHOWS THEIR NORMAL POSITION IN FAIR WEATHER.

The automatic action is secured in the case of sudden changes of temperature by means of a thermometer of special form which operates a mechanical device for releasing the mechanism. Such a device is placed in the central post and operates the different shelters from a distance.

Although the details of the automatic device are not as yet made public, the general method of action will be easily understood. The device consists in the combination of a thermometer and a catch device which is operated by a counterweight. In this case the best form of thermometer is found to be one based on the principle of the expansion of metals, or double-strips form made of two strips of different metals soldered together. The unequal expansion of the metals causes the free end of the strip to move, and this when connected with a needle gives the movement of the latter over a graduated dial. Around the dial moves an adjustable point, which can be set opposite the part of the scale corresponding to the temperature determined upon for operating the mechanical device. When the needle strikes this point it causes the movement of a set of levers properly adjusted so as to allow a very small force to operate a heavy mechanism. A counterweight of 600 pounds is thus released when the proper temperature is reached at the minimum or maximum, such as for extreme heat or extreme cold. Leading from the counterweight mechanism is a set of wires laid somewhat upon the manner of operating railroad signals. The wires or rods lead from the central post to the different protecting devices, and the latter can naturally be made to cover a large extent of territory, seeing that the device can be operated for great distances, and its action is simple and effective.

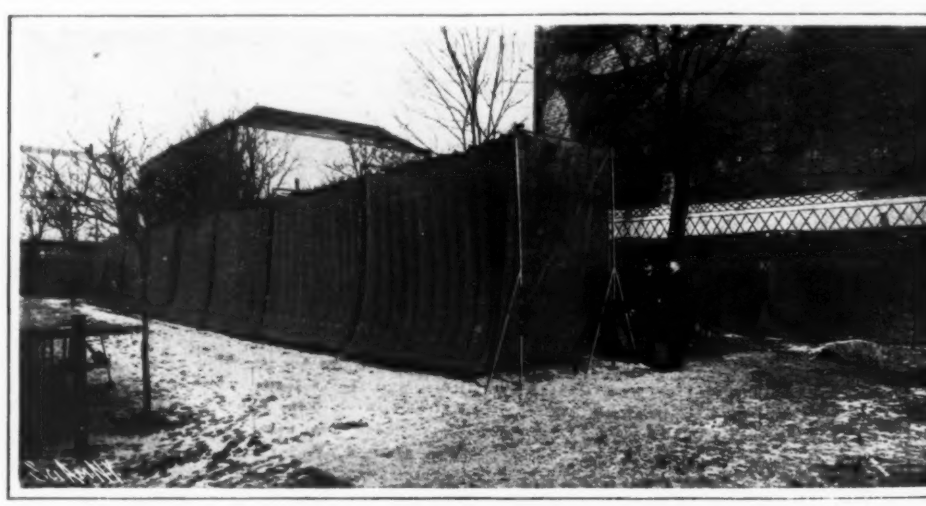
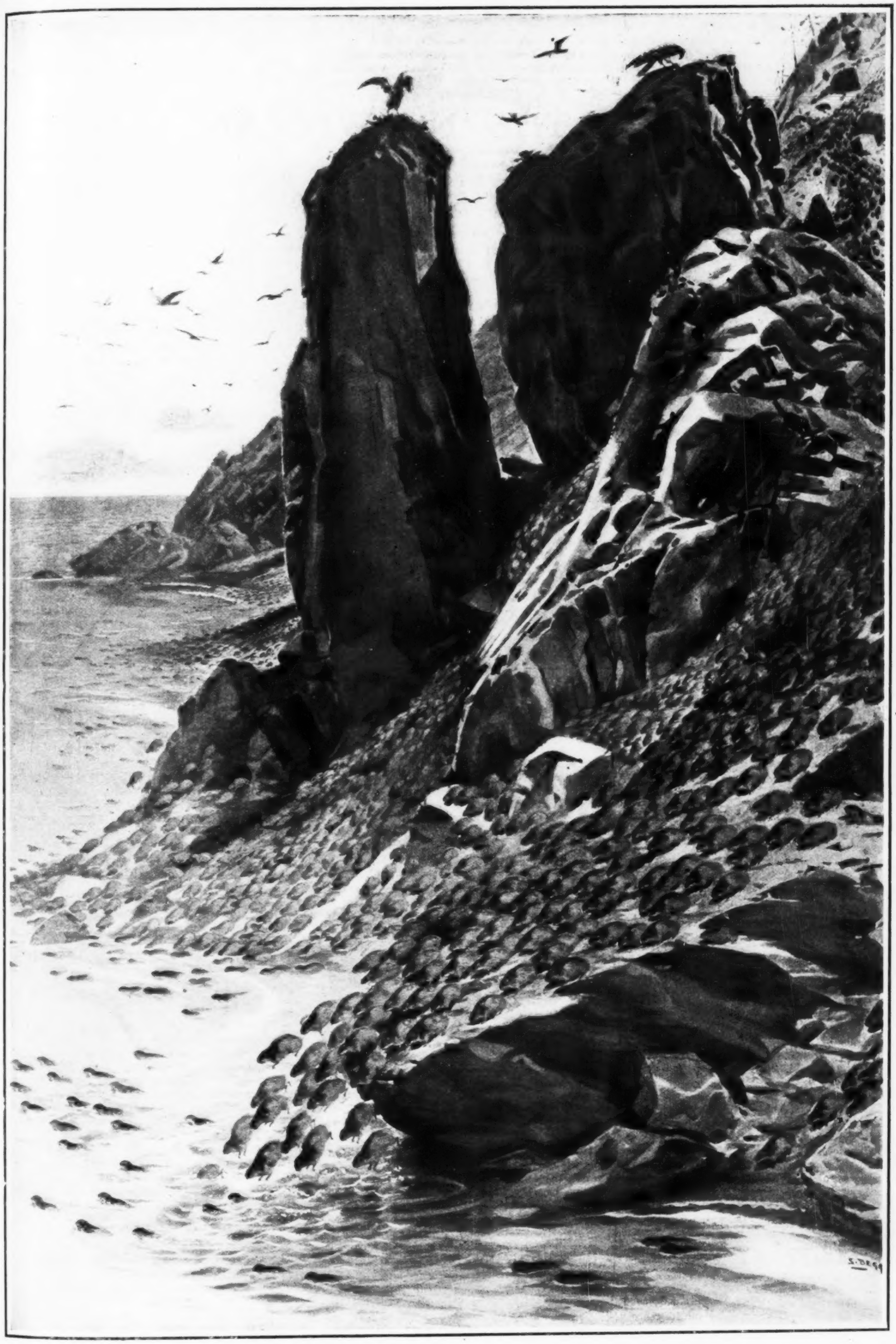


FIG. 3.—PROTECTION AGAINST FROST IS AUTOMATIC; IN CASE OF SUDDEN RAIN OR HAIL THE MACHINERY MAY BE ELECTRICALLY SET IN MOTION FROM A DISTANCE.

Supposing that a sudden frost comes on, the thermometer descends and causes the release of the counterweight. At once the protecting coverings over all the tract in question are drawn over the plants, and shield them from the cold. Should the temperature rise again to a point where the plants can be uncovered, the action of the device carries this out in the inverse sense. An important point of the present system is the use of electric signals for showing when the protecting action has taken place. As soon as the apparatus has properly worked, an electric contact mounted upon the protecting device at the distant point comes into play and rings an electric bell which is mounted in the central post. The bell continues ringing until the current is cut off by the attendant. Such electric bells can be located not only in the central post, but also at different points of the ground, so that the working of the device can be observed from a number of points covering a wide territory. Thus the proprietor is informed without needing to leave the house as well as if he were upon the ground. The arrangement of

FIG. 2.—ON THE APPROACH OF FROST OR HAIL THE STRAW MATTING SWINGS VERTICALLY INTO POSITION AS A ROOF; THE ROOF AND SIDE SCREENS OF CANVAS ARE DRAWN; AND THE BLINDS FALL TO PROTECT THE TREES AGAINST THE WALLS.

AN AUTOMATIC DEVICE FOR PROTECTING VINES OR FRUIT TREES.




From the Illustrated London News.

SELF-EXTERMINATION IN THE SEA: THE EXTRAORDINARY MIGRATION OF NORWEGIAN LEMMINGS.—[SEE NEXT PAGE.]

The migration of the lemming, a Scandinavian relative of our own water-vole, has long been a puzzle to naturalists. The lemmings, which are very rapid breeders, assemble at certain times in the hills where they make their home, and march in vast hordes through the lesser-known Norwegian country on their way to the sea; and, having reached it, take boldly to the water, where most of them perish. The migration of the lemming is followed with great eagerness by all carnivorous birds and by certain of the little animals' four-footed enemies, and their ranks are very considerably thinned. On their road to the sea the lemmings eat every green thing they come across as relentlessly and completely as the locusts do in Africa.

the electric signals is very simple, and needs only the usual wiring and a few cells of battery. At the same time the electric wiring can be used to operate the second part of the system. In the case of frost, the desired action is caused by the thermometer, but this will not serve to provide for sudden hail storms, rain or snow.

In this case it is necessary to operate the device by hand, either on the spot or from a distance by means of the current. It is evident that by the use of an electromagnetic catch device upon the counter-weight levers, these can be released from any of the outlying signal posts which we have already mentioned, and at each of the posts is placed a push-button or other form of switch for throwing on the current.

# MIGRATION OF THE NORWEGIAN LEMMING.

## THE STRANGE FLIGHT OF A RODENT.

BY W. P. PYCRAFT.

AMONG the wonders of animal life the migrations of the lemming have always held a very prominent place; and this because of the vast scale on which they take place, and the sporadic nature of their occurrence.

The Norwegian lemming, it may be remarked, is a native of the mountains of the Scandinavian Peninsula; and is a near relative of our "water-rat."

As is the nature of their tribe, they multiply with exceeding rapidity, so that at last the surplus population is compelled to seek new feeding grounds. Accordingly, they descend the mountains in great hordes, and clearing up every green thing before them, finally reach the seashore. This, however, is no barrier to their determined onward march. Prosecuted so far in spite of every obstacle, they now boldly plunge into the water and strike out, apparently for some imaginary Elysian Fields, with the result, of course, that not a single lemming of the whole troop escapes a watery grave!

During this march, which takes about three years, they are subjected to a fierce and unrelenting persecution. Eagles, hawks, and owls harass them from above, foxes and other carnivora attack them on all sides, while even the reindeer are said to join in this work of devastation. Thus thousands upon thousands meet with violent deaths of one kind or another, and thousands and thousands more fall by the way from the more subtle attacks of disease.

Hitherto it has been supposed that the journey toward this imaginary Promised Land invariably ended in the extermination of every participant in this terrible march. It would seem, however, from recent observations, that the invisible Pied Piper which lures on the host leaves a few individuals by the way, which remain at intervals along the route to form small, new settlements. Thus, in the autumn of 1906 there was a lemming migration in Sweden, and in the succeeding spring and summer numbers were found breeding in the coast districts, where they soon increased sufficiently to work considerable damage to the vegetation.

It now remains to be seen whether these colonies will gradually die out, or whether they will still further increase. Since a vigorous war is gradually springing up here, as in this country, on so-called "vermin," in the supposed interests of game-preserving, it is probable that they will increase. The fact that they have not hitherto done so, but have been confined to their mountain fastnesses—save for these occasional emigrations—is probably due to the circumstance that "vermin" were sufficiently numerous to protect the country.—Illustrated London News.

# PHOSPHORESCENT BODIES.*

## SOME NEW RESEARCHES.

BY PROF. G. URBAIN, OF THE PARIS UNIVERSITY.

A CLASS of bodies which have been but little investigated up to the present, but which afford a wide field for research, is that class of phosphorescent substances which are generally composed of sulphides of the alkaline earths. It is these bodies which go to form what is commonly known as "luminous paint." The author has carried on some investigations upon these bodies, especially by the use of spectrum analysis, and comes upon some unexpected results.

These phosphorescent bodies were prepared in the first place without any real knowledge of their properties and somewhat by chance, as it was found that to give a good luminous substance having sulphide of calcium as a base, all kinds of lime could be used. With lime coming from different sources, were obtained more or less luminous bodies whose light had varying colors. The producers were ignorant of what influence could produce such different results, and the whole question was very obscure. M. Verneuil succeeded in solving this problem by a series of analytic researches on the composition of these bodies. He showed that the alkaline earth sulphides owed their phosphorescence to the presence of certain impurities. Among the latter, managanese and bismuth are especially active. The presence of a small quantity of alkali greatly increases the phosphorescent power of these mixtures, which in order to become very luminous, should have been at first heated to a high temperature. M. Verneuil proved these facts conclusively by starting with pure materials and preparing sulphides which were more phosphorescent under the exciting action of light than what had been obtained heretofore. Thus decisive experiment shows that the phosphorescence of sulphide of calcium is not a property of special kinds of lime and of particular sources. The presence of traces of impurities is necessary for the sulphide to become phosphorescent.

It is only by spectrum analysis, which expresses the nature of the radiation by numbers, that we can have a complete observation of such bodies. This work has lately been undertaken by Messrs. Lenard and Klatt, and they fully confirm the results obtained by M. Verneuil.

The phosphorescent sulphides are not the only bodies which give off such radiations under the influence of light. This property belongs to a considerable number of bodies having a widely varied composition. But in general these phosphorescences are so weak that they are badly adapted for observation. On the other hand, the method of exciting by means of light scarcely allows of a study of the "persistence" phenomena. Before the researches of Lenard and Klatt, this work had been thoroughly pursued by Becquerel, who showed the generality of the phenomenon. However, the greater part of the substances thus studied gave in the spectroscope only very wide diffused bands which were badly defined. These conditions are unfavorable for the study of a phenomenon in which the nature of the radiations has a preponderant part. Thus we understand why our knowledge in this field has been so limited.

The method of excitation by means of the cathodic rays is far superior. The work of Sir William Crookes and M. Lecoq de Boisbaudran shows that an unlimited number of mineral substances show extremely bright phosphorescence in the vacuum tubes. Sir William attributes the phosphorescence sometimes to the principal masses and sometimes to the impurities. He shows that the compounds of the rare earths when under the action of the cathode rays give phosphorescences which are shown in the spectroscope as a system of narrow bands or even rays. But the diversity of his opinions, which were often contradictory, prevented him from determining with precision the main laws of the phenomena, so remarkable and numerous, which he discovered. The work of M. Lecoq de Boisbaudran, which is not less extensive, is to be recommended from the clearness of the consequences which he was able to draw from it. The researches undertaken by the author during the last few years fully confirm the conclusions of the latter scientist. We will give a brief account of these researches.

Experiment shows that all phosphorescent substances gradually lose that quality as they are purified. On the other hand, the different impurities give to the same principal mass a series of different phosphorescences corresponding to distinct spectra. The spectra of cathodic phosphorescence are therefore not to be attributed to the main mass of the substance, but as in other cases, to the impurities which they contain. It is the electrons of these impurities which play the principal part, and the main mass serves only to dilute the active matter so as to form as it were a solid solution. In such phenomena we may call the principal mass the "diluant" and the active matter the "phosphorogen."

Thus all notably phosphorescent substances, excited in any way, are mixtures of at least two bodies, the phosphorogen and the diluant. We find that phosphorescence, especially when produced by the cathode rays, is a phenomenon of very great sensitiveness. It often suffices to have a millionth part of a phosphorogen in a suitable diluant in order to realize a phosphorescent substance. But neither the one nor the other when taken separately will give the effect. The phosphorescence of intimate mixtures of phosphorogen and diluant, in which the value of each varies from 0 to 100 per cent, must necessarily pass by a maximum value giving the highest phosphorescence. The maximum always corresponds to relatively considerable proportions of the diluant, and the amount of the phosphorogen is generally of the order of 1-100. Not all the inorganic bodies can act as phosphorogens or diluants. A body having a metallic conductivity has never been found to serve as a diluant, but the oxides and sulphides of the earths are found to be good diluants. The metals and those of their sulphides which conduct electricity never act thus. However, all the bodies which have just been cited, when they are impure and above a certain temperature, have an electric conductivity of the electrolytic order. They are ionizing bodies. The impurities which they contain are thus ionized and give an electric conductivity to the main mass.

In aqueous solutions, it is not doubtful that the phosphorescence is a property of the ions. M. Lecoq de Boisbaudran observed that if we cause a long spark to pass between certain aqueous solutions and a metal electrode, the liquid is illuminated at the point where the spark occurs, especially if the liquid is the positive pole. The bodies which give this effect in solution are the same as those which act as phosphorogens when in solid solution. These phosphorogens are elements such as bismuth, manganese, certain rare earths and even radicals such as ammonium. It is probable that all the metals, or more exactly, all the positive electrolytic ions, can act thus and emit radiations of phosphorescence in one or another part of the spectrum. In aqueous solution, the nitrates, chlorides, sulphates, etc., of the same phosphorogen will give the same spectrum in a well-diluted solution. This spectrum should thus be attributed to the positive ion, and it is this which forms the true phosphorogen.

These experiments show the part which the dissolvent and the phosphorogen play in the phenomena of phosphorescence. It seems rational to admit that it is the same, in a certain degree, for the solid solutions. In these the ions of the phosphorogen manifest themselves in different diluants by the spectra, which without being identical show marked analogies. In the solid solutions the ions are not free, and we note that free ions would give identical spectra in different dissolvants, but in view of the great analogy of the spectra, we can admit that the ions of the phosphorogen acquire, under the influence of exciting radiation, a

* Abstract.

certain liberty with respect to the ions of contrary sign which in the molecule act to neutralize their charge. It is probable that this freedom is favored by a great dilution of the phosphorogen in the diluant. This great dilution must act to lessen the stability of the atomic edifice, and it is the electrons of the diluted matter which are the most moved under the influence of the cathodic projectiles, and in general by exciting rays.

Coming to the phenomena of dilution, it is noted that in a phosphorescent system composed of a single diluant and one phosphorogen, we often find that the color of the phosphorescence changes continually as the proportion of phosphorogen increases. The spectra of phosphorescence undergo marked variations. According to the law of the maximum effect, the brightness of the spectrum should lessen as the concentration of the phosphorogen increases, or again as it diminishes on the other side of the maximum point. Thus each band of the spectrum should pass by a maximum. Comparing the spectra with each other, the author finds that all the bands of a spectrum do not pass at the same time by their maximum brightness as the amount of phosphorogen changes. Each band follows individually the law of the maximum, but these points do not necessarily coincide. Some groups of bands have already diminished while others are increasing. The spectrum of a phosphorogen which is concentrated may be quite different from that of a diluted phosphorogen, and we have thus very marked differences in the color of the phosphorescence. In general, this color, given by a concentrated phosphorogen, corresponds to a mean wave-length which is less refrangible than that due to a very diluted phosphorogen in the same diluant. When in concentrated solution in gadolina (the earth corresponding to the element gadolinum) the element europium gives a red phosphorescence. This changes to light orange color in a very diluted solution. The element terbium, when in concentrated solution in carbonate of lime, gives a green phosphorescence, but this is blue in a dilute solution, etc. The phosphorescence of manganese in carbonate of lime is orange, but seems to change toward the blue in very dilute mixtures.

We also have the case of complex systems, one of which is a single phosphorogen in two diluants, and we find like changes in the spectra. Each of the two spectra does not seem to be much changed as to the wave-lengths of its bands, but there is not a simple addition of the two effects, since one spectrum can be completely masked by the other. In the case where I used as diluants mixtures of carbonate of lime and gadolina, and as phosphorogen europium, I observed in the visible spectrum with certain mixtures the spectrum of europium alone acting in the gadolina, although the mixtures contained nearly 95 per cent of carbonate of lime. On the contrary, in the ultraviolet regions, I found the spectrum of gadolina acting in the lime. The gadolina acts in the visible spectrum as a diluant and in the ultra-violet as a phosphorogen. With two phosphorogens and one diluant the case is as complex as the above. According to the proportions, we observe the spectrum of one of the phosphorogens or the other, or again a mixture of the two. We also observe a phenomenon noticed by Sir William and M. Lecoq de Boisbaudran. The phosphorescences neutralize each other, and one of them may mask the other, and inversely.

By the above phenomena we perceive that the phosphorescence is a subject of investigation which has a wide range and whose observation has been but little carried out as yet. It is probable that it will soon be one of the most fertile and interesting departments of spectrum analysis and physical chemistry.—La Revue Scientifique.

# THE RICE BEER OF THE JAPANESE.*

## HOW SAKÉ BEER IS MADE.

BY DR. W. DONSELT.

Among us, beer is brewed from malt and hops, whereas in Japan rice is employed for brewing purposes. The so-called saké beer is the national beverage of the Japanese. While our beer possesses a higher extract content, that of the rice beer is comparatively low with a higher alcohol content; its color is similar to that of Rhein or Mosel wine, and its taste mild like that of our beer. The saké beer of the Japanese has a most peculiar aroma, which is particularly conspicuous, inasmuch as they drink their beer in a warmed condition. The materials out of which this beer is prepared are rice, water, and "koji."

The rice which is employed in this production is hummeled or awned, but not cleansed. The grains of rice are then poured into a wooden mortar constructed in the ground, and then crushed by means of a wooden hammer or pestle, which is raised with the aid of a lever or hoisting jack and drops upon the rice by its own weight. In this way the grains are ground together and against each other, the husks, and generally also the germs, being thus removed. If the grains have been sufficiently pounded, they are sorted, the whole grains being separated from the broken ones and from the bran. Only the former are utilized for the preparation of "koji" of the finest quality. The loss in this operation amounts to about 25 to 40 per cent. The whole grains are then washed as frequently and as thoroughly as possible, in a basin with water, until they have become entirely clean. They are then allowed to soak for a full night, when they are poured into a kind of clarifying vat, the bottom of which is pierced by holes and covered by a cloth lining. Steam is conducted into this clarifying vat from below, in order to gelatinize the starch of the grain. The procedure is usually that of placing the clarifier upon a large iron boiler in which water is heated. The germs which were not removed in the previous steeping are now separated off, and the rice becomes flexible and assumes a uniform horny appearance.

This "mi," as the Japanese call the mass thus prepared, is then spread out upon mats, being thus cooled to a temperature of 20 deg. A yellow powder, called "tané," is now added to the grains, consisting principally of the spores of a mold fungus, *Aspergillus oryzæ*, but which also contains several cells of a peculiar yeast. After this powder has been thoroughly mixed with the boiled rice grains, the mixture is allowed to remain at rest for about twenty-four hours in the coldest part of the cellar at a temperature of 26 deg., and an additional period of about twelve hours in the rear part, spread out in a thin layer upon wooden plates. The contents of each plate are then gathered together in little heaps, which are left untouched for five to six hours. In the heap there is naturally a considerable rise in temperature due to the development of spores; the mycel formed envelops the rice grains, and unites and joins them together to a compact mass. To avoid too great a generation of heat, the heaps are spread out several times, allowed to cool, and then gathered into heaps again, subjecting them to vigorous stirring at frequent intervals. The "koji" has acquired a temperature of 15 deg. to 27 deg., depending upon the conditions of its sojourn in the cellar, the temperature of the air in the cellar varying from 8 deg. to 13 deg.

In the preparation of rice beer, the "koji" is used in a similar manner as the malt in the production of beer. In most cases, the saké brewer prepares his own "koji." The cellars which are employed in the preparation of "koji" are in general situated 5 to 6 meters under the ground. Access to these cellars is usually so arranged, that a long passage must first be traversed, whereby too rapid a cooling of the cellar is avoided. If the cellar has been empty for a while, it must first be heated for the manufacture of "koji," but later on the heat generated by the mold-fungus usually suffices to keep the cellar at the desired temperature. In the upper part of the passage a warm current of air is conducted off, whereas a cold current enters from the ground, so that provision is always made for a renewal of air in the cellar.

The growth of the fungus lasts about 36 to 48 hours, and during this time, through its enzymatic activity, the starch of the grain is in part converted into maltose and dextrose.

As soon as the preparation of the "koji" is finished, we enter upon the actual brewing process. Boiled rice, "koji," and water are mixed together, and the sugar thus generated is allowed to ferment. The liquid is separated from the solid ingredients, and is clarified, sterilized, and stored.

As to the condition of the water, this plays a most important role in the production of saké. Good drinking water is undoubtedly adaptable for the production of beer, though not always for the preparation of saké. The water must in fact contain mineral salts, for the rice, after its working up, has in part been deprived of its mineral salts, such as phosphoric magnesia and potassium, which are necessary for the development of yeast. The rice-beer breweries are almost always situated in localities where the water is especially suitable for the manufacture of saké beer.

In the brewing, the "moto" is first prepared. For this purpose, 40 parts of "koji" and 120 parts of water are taken to 100 parts of steamed rice, and besides a quantity of saké yeast sufficient for the fermentation, is added. After thoroughly mixing this composition in a wooden vat, and mashing it for two to three hours with a wooden rod, the mass is allowed to stand for two to three days until the whole becomes gradually liquefied and the grain is saccharified. The yeast now begins to multiply—most prolifically at a temperature of 23 deg. — under generation of gas, which sets in after two or three days. After frequent mashing, the temperature is raised after 24 hours, to 30 deg. to 35 deg. A very vigorous fermentation then sets in, and the temperature rises to over 32 deg.; then after several days this gradually diminishes, and the mass is cooled off. The "moto" is now finished, its taste being bitter, weakly acidulous and piquant.

The main fermentation then ensues. To the "moto," a mixture of rice, "koji" and water is added, and in fact first "koji" and water. If after about 12 hours this mass has become liquefied, the rice is added. After a shorter interval than in the case of the "moto," fermentation again sets in. When this mixture has been divided into two equal parts, rice, "koji," and water are later again added and once more for the third time, and the whole mashed every two hours. At the end, the contents of the small tubs are combined in a large vat, and this is then mashed every two to three hours. The temperature gradually rises to 28 deg., and after six days the fermentation reaches its maximum; the temperature then declines and the fermentation gradually ceases. The whole is then poured through linen bags, and the residuum, which consists principally of unconverted rice grains, is pressed out with the aid of a lever. The turbid trickling liquid is gathered up in vessels which are sealed hermetically and then left to clarify in cool cellars. In the spring the clear liquid is drawn off, after which it is sterilized by heating it at a temperature of 60 deg. The foam which in this process forms on the surface, is removed, and the saké-beer is filled into hermetically closing cedar-wood barrels, which are then stored in a cellar at as constant a temperature of 10 deg. to 16 deg. as possible. Samples must frequently be drawn from this saké-beer to establish whether infection has set in. During the storing, the saké-beer experiences an improvement, inasmuch as the fusel oil created during the fermentation constantly decreases in amount through oxidation.

The saké-beer is almost solely the national beverage of the Japanese, for but very little is exported. Its sale price varies from 30 to 100 pfennige (7 to 24 cents) per liter, depending upon its quality.

* Pure Products.

### A STERILIZING OVEN FOR BOOKS.

The disinfection of books is a difficult task which cannot be performed thoroughly or without injury by simply heating the closed volumes in an ordinary oven. M. Berlioz has invented an oven, provided with a device for the evaporation of aldehydes, in which closed volumes of any size can be completely sterilized at atmospheric pressure and a temperature below the boiling point, without the slightest injury to covers, paper, or binding. The only precaution required for delicate bindings consists in wrapping the volumes in paper. A severe test of the apparatus was made in the case of a volume of 1,300 pages, a page of which had been contaminated to the inner margin with pus and fecal matter. The book was completely sterilized in two hours at a temperature below 200 deg. F. On the other hand, very delicate bindings showed no ill effects from a two hours' sterilization in the oven.

The simplicity of the process, which requires no elaborate precautions and can be conducted by any intelligent person, adds greatly to its value and should cause it to be widely adopted, for many diseases can be communicated by means of books. The process is also useful for the preservation of books, which are subject to various fungous and bacterial diseases of their own.

**Messrs. Palerno and Cinngolani**, the inventors of "tachyol" (fluoride of silver), an antiseptic employed in surgery, have found that a solution of 1 part in 500,000 of water will destroy all germs, including *B. subtilis*, its germicidal effect being much greater than that of chlorine, bromine, or ozone.

# HYDRAULIC MINING IN CALIFORNIA.

## HOW THE DEBRIS IS IMPOUNDED.

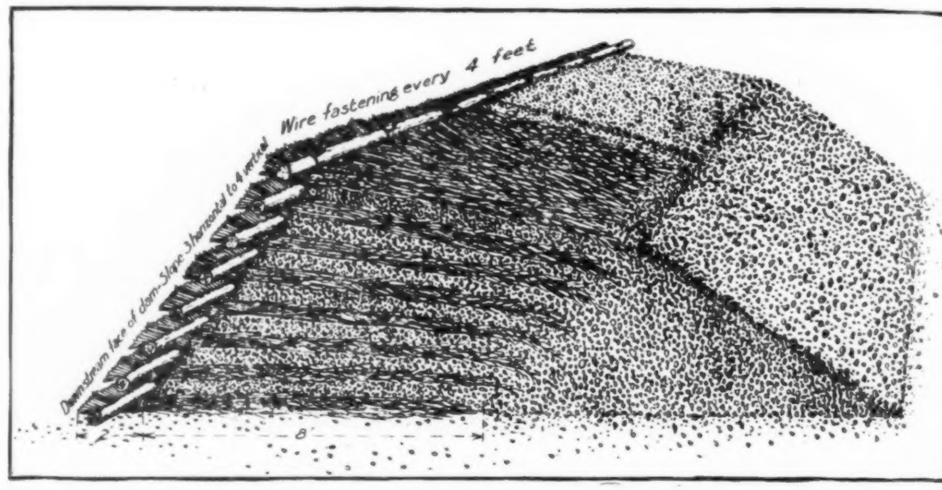
BY MAJOR WILLIAM W. HARTS, CORPS OF ENGINEERS, U. S. A.

THE richness of the gold fields of California, discovered a generation or more ago, often seems almost fabulous. Scarcely a stream on the western slope of the Sierras but held in its gravel bed quantities of this precious metal. When these streams had been robbed of the treasure by the early miners, it was found that enormous wealth could be extracted from the old gravel beds of the rivers of the Tertiary period. Thousands of men worked for years washing this gravel, and hundreds of millions of cubic yards of these ancient deposits were thus washed through their sluice boxes into the streams leading to the great rivers of the State.

This mad rush for gold at the expense of the future development of the industrial conditions of the valleys was aided in various ways by both the State and national governments, and little or no thought was then given to the injuries which might be caused later by these operations. But as the population of the valleys increased, and the agriculturists found that the accumulation of mining debris was working incalculable injury to their farms by often covering their lands and by causing widespread overflow, a growing hostility arose toward the miners, who were believed to be responsible for such injurious conditions along the rivers. The hostility thus engendered grew to such magnitude, that finally both State and nation awoke to the seriousness of conditions, and for years engineers and legislators have been endeavoring to solve the debris problem.

The problem of what to do with the debris resulting from years of hydraulic mining, which still remains in large quantities in the upper rivers and in their mountain tributaries, and how to protect the valley farms from further injury due to the downward flow of this material, has been the subject of both State and national investigation, until finally an act was passed by Congress in 1893 providing for a federal board composed of three engineer officers of the army, to be called the California Debris Commission. This commission found a condition for the improvement of which there was neither precedent nor previous experience, and everything had to be originated *de novo*, as no such condition exists elsewhere in the world.

The first efforts of the commission were directed toward an examination of the mines, in order to see what relief could be given to the miners, who were clamoring for permission to resume mining, which had been stopped by court injunctions at the instance of the farmers of the lower valleys. It was found that the construction of dams in the canyons below the mines would in most cases store all the material that would be removed. After many years of study of the problem, it was seen that either the log-crib dam or the brush dam would answer the purpose for all small brush. It may be twenty feet high, and at least ten feet long. These dams must comply strictly with the specifications of the commission, and before beginning to mine, the hydraulic miner must obtain permission or license of the California Debris Commission, which

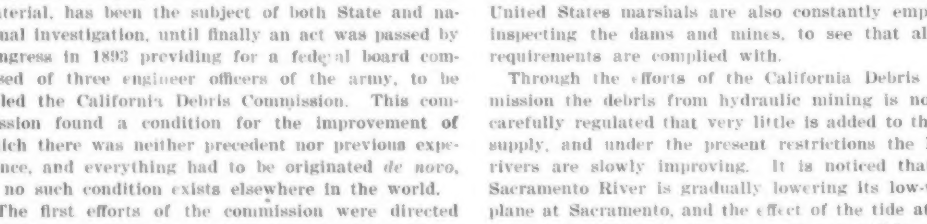



BRUSH RETAINING DAM WITH END CUT AWAY TO SHOW CONSTRUCTION.

is not given unless all the conditions specified as to their dams have been complied with. In addition, a monthly report is required by the commission showing the quantity of material mined, the amount of water used daily, and the conditions of the dams. Deputy United States marshals are also constantly employed inspecting the dams and mines, to see that all the requirements are complied with.

Through the efforts of the California Debris Commission the debris from hydraulic mining is now so carefully regulated that very little is added to the old supply, and under the present restrictions the lower rivers are slowly improving. It is noticed that the Sacramento River is gradually lowering its low-water plane at Sacramento, and the effect of the tide at this place is beginning to increase very perceptibly.

The other aspect of the duty of the commission is the study of the rivers of the Sacramento and San Joaquin systems, in order that these navigable streams may be restored to their former condition as far as may be needed. The first step after controlling the output of debris from the mines was the treatment of the larger tributaries, to prevent the enormous quantities of debris in their beds from reaching the navigable streams. A general line of work was first adopted on



FACE OF THE YUBA RIVER DAM.

mines. These two types of dam are now in general use for impounding the debris.

The log-crib is the usual type. It consists of a "cobhouse" crib made of large logs, which are notched and drift-bolted together. It is filled with quarried rock and chinked against leakage. The limit of height placed on these dams by the commission for safety is forty feet. The brush dam is constructed with strong, live

the Yuba River, that was believed would be applicable. This consisted of three divisions: 1. The construction of moderately high dams in the foothills, to catch and store the heavy material that is deposited on high grades. 2. Embankments and basins lower down, to form settling pools for the finer debris. 3. Training walls along the lower rivers, to control the flow in selected channels and prevent the river from overflowing and moving the large bodies of debris lying outside the walls.

It was decided to commence operations as early as practicable on the Yuba River, as this stream suffered more from mining debris than any other, and was doing more damage to the navigable rivers than all the others combined. The project as outlined by the commission called for the expenditure of $800,000, half of which was appropriated by the State and half by the National government. The project provided first for barriers across the river just below Smartsville; second, a cut at Daguerre Point through which to divert the river at high stages with settling basins for impounding fine detritus during the remainder of the year; and third, training walls about 2,000 feet apart extending from Daguerre Point to Feather River, to confine the flow to a selected channel. A dam in the Yuba was first tried by the State of California some years ago for restraining debris, on which work Mr. James B. Eads was consulting engineer. This was destroyed by the first high water, which it may be said is ordinarily greater than one-fourth the flow of Niagara Falls.

The first dam constructed by the commission, of brush, rock, and gravel, was washed out, and then a modified brush dam was tried, made of brush fascines loaded with rock. This was all destroyed by the first high water. A stronger dam has now been constructed of piles, large rock, and concrete blocks. It appears that this has solved the problem, as it has now passed safely through three high-water seasons without injury, and is the first dam to withstand a single freshet in the lower Yuba River. It has already stored over 3,000,000 cubic yards of debris.

The work of completing the project is now progressing rapidly. The diverting barriers and settling basin near Daguerre Point, together with the training walls lower down, are being constructed. This work has now progressed far enough to assure the commission of its ultimate success, and to permit the commission to study the other problems of the Feather and Sacramento rivers, which is now being done. Meanwhile a survey party has been kept in the field surveying Bear and American rivers, with a view to preparing plans for their treatment, either along similar lines or by some new project, such as by dredging. The commission has recently examined the method of caring for the debris by dredging in the navigable rivers, and found it preferable to the settling basin method, at least for the treatment of the Bear and American rivers. By dredging in the navigable rivers and removing the debris as it is brought in by these tributaries, many incidental benefits may be achieved, now that the Yuba has been rendered practically harmless. The navigation in the Feather River may be restored, that on the Sacramento improved, the mining debris disposed of, and by placing the material along the banks in levees, the flood water will soon be controlled and reclamation of the farms adjoining incidentally assisted. This will probably be the method recommended in all the future work of the commission. Should this plan be adopted by the State and Federal governments, it will probably solve the problem north of Sacramento. If this should occur, the attention of the commission will then be turned to the problems of navigation and flood control in the Sacramento Valley.

Naturally, it is impossible, in an article of this sort, to go into detail of the work that has been done and is contemplated. The California Promotion Committee, at Union Square, San Francisco, has all data relating to this work, and will be pleased to answer questions relating to the subject. The California Debris Commission is solving questions and problems that have never before been solved, and the work already done and results accomplished are conclusive indications of the thoroughness and completeness of the plans that have been carried out.

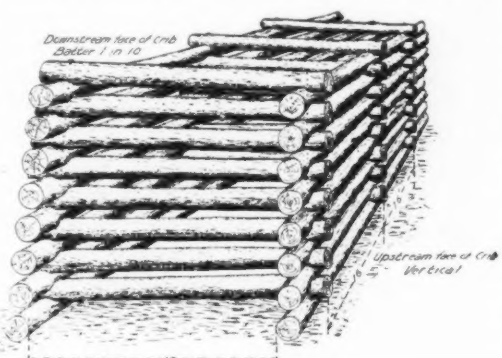
## THE MYTH OF MALLEABLE GLASS.

Even at this late day it seems necessary to say something in regard to malleable glass, but the subject has been so well taken care of in a little book published about three hundred years ago, and now somewhat rare, that we quote liberally from this little publication of Neri,* for, strange to say, it contains most of the fundamentals regarding the chemistry and manipulation of glass and contains sound information for the glassmaker of to-day:

"Concerning the malleability of glass, whereon the Chymists build the possibility of making their elixir, take their weak foundation from Pliny, lib. 36, cap. 26. They report, saith he, that when Tiberius was emperor, there was invented such a temperament of glass that it became flexible, and that the whole shop of the artificer was demolished, lest the prices should be abated of the metals of brass, silver, and gold, and this report was more common than certain. Now, Pliny lived in the time of Vespasian, who was the third emperor from Tiberius, so that it appears this report continued long. Many after him relate the same, though with some difference, Dion Cassius, lib. 57, thus: At that time when a very great portico at Rome inclined to one side, a certain architect (whose name is unknown, because Cæsar through envy forbid it to be registered), strangely set it upright, and so firmed the foundations on every side, that it became immovable. Tiberius, having paid him, banished him from the city, but he returning (as a supplicant) to the Prince, wittingly let fall a cup made of glass, and when it was broken remade it with his hands, hoping thereby to obtain pardon; but for this very thing he was commanded to be put to death. Isidorus affirms that the emperor in a chafe hurled it upon the pavement, which the artist took up being bartered, and folded like a vessel of brass; he then took a hammer out of his bosom and mended the glass, which being done, the emperor said to the artist, 'Doth anyone else know this way of making glass?' When he denied it with an oath, Cæsar commanded his head to be cut off, lest this being known, gold should be esteemed as dirt, and the prices of all metals should be abated. And, indeed, if vessels of glass did not break they would be better than gold or silver. These three grave authors, Pancirollus and others follow, only telling it as a hear-say, but Mathesius, Goclenius, Valensis, Quatriami, Libavius, and all the tribe of the Chymists, assert it with great confidence, affirming that it was done by the virtue of the elixir; but for all this confidence of theirs, Pliny only relates this story with a *ferunt*, they report, and with a *fama*, the report was, and thirdly, more common than certain, which thrice repetition of such like words, sufficiently argue his small belief of the story. It had been enough to have introduced this improbable relation the usual way with a *ferunt*, and hereby sufficiently have provided for his reputation, which, at most, proves only that some small credit was by some few given to it, but a disbelief in the wiser sort. For what can such words as these (they say such a thing, but the report is most uncertain) import, but a diffidence in the relator? And 'twas but a fama, no naturalist, poet, nor historian deliver it; no record of the person, nor unusual punishment, which is strange, when their books abound with observations of whatsoever rarely happened. And is it probable that the emperor himself should not lay up this glass as a secret in his choicest archives, and have transmitted it down to his successors, as a thing worth the keeping, being the first of that nature ever made in the world, and perhaps the last, the artist being put to death. And yet within a few years all this most rare invention and strange punishment vanish into a report only. All then was but *vox populi* and Romani, too, nay, of the cruelty of a Nero, too, all which might easily keep up this fable. But why did Pliny then relate it? Surely, to please and follow his genius, which was to commit to writing whatsoever was rare in art and nature, as his nephew in his epistles, and this present work witness. Now, on this account he might take occasion, in a thing perhaps he judged not impossible, to commend that present age (should after times produce any such effect) and so ascribe the invention thereof to his own nation. Besides 'twas but such a temperament of glass that rendered it flexible. And is it credible that after ages should not light on it, especially in a thing so commonly practised, and where to so few, but two materials only are required. Or what means fame by the undervaluing of gold and silver? I confess I see no inconvenience to the emperor, nor his gold and silver value, by this invention, but many ways advantage, nor any force of consequence in Cæsar's words. But so much of Pliny's testimony. And what! shall the borrowers from him gain more reputation than the

METHODS OF CHINKING DOWNSTREAM FACE.

first relator gave it? Surely no, especially since they have made such a commentary on Pliny's text, the words will not bear, and have with additionals molded it into a formal relation. Pliny saith, "Ut flexible esset," that it might be flexible. Dion comments, the man remade a broken glass (one degree to malleability), but Isidorus completes it, saying, with a hammer he mended it. Hereby you may see the degrees how this opinion came into the world, and by what strange piecings, variation, and interpretations, it hath been fomented to make that seem credible to after ages, which Pliny relates as a vulgar tradition, adding thereto a censure of uncertainty, which the Chymists,




LONG CRIB DAM BEFORE CHINKING OR FILLING.[1]

to keep up the opinion of their omnipotent philosophers' stone, omit, and turn Pliny's flexibility into malleability, as if there were no difference betwixt flexible and malleable, whereas all bodies are in some degree or other flexible, though none but metals malleable. A green stick, Muscovie glass, and infinite other things will bow very much, whereon the hammer, notwithstanding, hath no effect as to dilatation and formation into thin plates, such as things called properly malleable have. And that glass is in some degree flexible of itself 'tis apparent, for fine crystal glasses made very thin and well annealed will bear some small, yet visible, bending. And I have had tubes made twelve foot long and longer for the mercurial experiment, which being filled therewith would bend exceedingly; so that I am prone to think that if there were anything at all in this narrative of Pliny it might be this: That whereas their glass before this time was most brittle, as being made of saltpeter, and the art of annealing it (not mentioned by Pliny) unknown, and consequently must break with the smallest force. Now, this artist might invent and show such glass as might accidentally bear a fall, or greater force, than what was formerly made, by making it of Kali, and superadding the way of annealing it, which might give occasion to fame, whereof Virgil, *parva metu primo, mox sese attollit in auras*, to add some circumstances (which is most common with the vulgar), and so to form this story related by Pliny.

"Now, as to the possibility of making glass malleable, I find not one argument, besides this report, unless by the Chymists who prove it per circulum, reasoning from their elixir to glass, and from glass to the elixir. And surely it were more feasible to make the one than the other, for in the making of the elixir the production is *tale ens ex non tali ente*, there being no resistance and incapacity in the matter *ex qua*. But in glass quite otherwise, for it is of its own nature the most brittle thing in the world, and to make it malleable a quality quite contrary to its nature must be introduced. Besides, diaphaneity is a property not communicated to anything malleable, and who would call that glass that were not transparent? As well may one name that gold which is not ponderous nor malleable, as that glass which is malleable and not transparent. Add hereunto that the nature of malleability consists in a close and throughout adhesion of parts to parts, and a capacity to the change of figure in the minutest parts, both which are inconsistent with the nature of glass. For the materials of glass, sand and salts, have such figures as seem incapable of such adhesion in every part one to another, for all salts have their determinate figure which they keep too, in their greatest solutions and actions of the fire upon them, unless a total destruction be wrought upon them, as many instances might evince, and that figure is various according to the salts. Saltpeter and all alcalizate salts are pointed, and by their pungency and causticness seem to be made up of infinite sharp-pointed needles. And as for sand, the figure thereof is various, nay, infinite, as it appears in microscopes. Now, how can any man imagine that such variety of figures in sand can so comply with the determinate figures of salt as to touch one another in *minimis*, which is necessary to make it malleable; whereas to make it glass it is enough that these two touch one another at certain points only, whereby such a union is formed, which is necessary to denominate glass, but wholly incompatible with malleability. And this union is that which makes in glass pores, from whence comes its diaphaneity as you have heard from Lucret. Besides, something said before declares that they both remain the same in the compound they were before. I shall conclude this argument and say that I conceive that nothing but the elixir will perform this effect, and that both of them will come into the world together."

* "The Art of Glass," by Antonia Neri. Translated from the Italian. London, 1692, and here reprinted from a paper read by George Macbeth before the Western Society of Engineers.

**A remarkable accident** occurred recently on a narrow-gage railway, known as the Balfour Line, in County Donegal, Ireland. The line crosses the Owencarrow Valley by a long viaduct. The wind, sweeping down the valley with terrific force, blew the early morning train from Burton Port off the line, and only the heavy railing on the parapet prevented the carriages falling into the river 100 feet below. Fortunately the engine kept the metals. Had it also been derailed its weight would probably have carried away the parapet, and the coaches might have gone with it, with fearful results. The viaduct is one of the most exposed in Ireland, and the Board of Trade regulations require trains to cross at a slow speed. There are also check rails, with a view to preventing derailments.

LOOKING ACROSS THE YUBA RIVER DAM.

# FORMATION OF MINERAL VEINS.—II.

## THE MAGMATIC AND METEORIC METHODS.

BY DR. WILLIS EUGENE EVERETTE.

Continued from Supplement No. 1687, page 288.

NORMAL REQUIREMENTS OF METALLIC ORES TO BE COMMERCIALLY VALUABLE.

23. THE necessary amount of metallic materials in an ore so as to make it commercially valuable depends entirely on the question of transportation; that is, all the questions of the transportation of the ore itself, of the transportation of the machinery and supplies for obtaining the ore, and also for extracting the metal thereof, and the economic transportation of the metal when thus obtained to a center of sale, purchase, and manufacture. These three mining items of transportation are vitally important when it comes to the question of economically extracting an ore from a rock, and extracting thereafter a metal from the ore.

24. The main lines of transportation may be so far away from a metallic ore (though even in large quantity) as to cause the ore body to be practically of no commercial value, by the simple reason that the transportation charges to a center of sale and manufacture are often greater than the actual market value of the metal in the ore when at the mine.

25. On the other hand, an ore vein may be extremely lean in metalliferous content, and yet, by reason of economical transportation to a manufacturing center that has demands for such a particular class of metal, such economical transportation may allow a very lean ore vein to be mined at more or less of a profit.

26. (1) Of course it is thoroughly understood that this implies the physical nature and mineralogical character of the ore vein, as well as the important condition of the particular kind of metal that is found in the ore vein. (2) Certain combinations of metalliferous rocks will produce mineral compounds that will always require very complicated metallurgical processes to extract the metals therefrom. (3) Other compounds of rocks will contain minerals from which the metal thereof is very easily extracted. (4) Even the combinations of the metallic elements in the ore may, in themselves, often greatly assist in and even retard the process of the economic obtaining into individual elements of the various metals that may be in the ore body. (5) A lead ore, when in combination with gold and silver ores, will greatly assist in the economic smelting and obtaining of nearly the entire gold, silver, and lead content. (6) But a zinc ore, in combination with lead, gold, and silver ore, greatly increases the complexity of the necessary metallurgical treatment, and thus causes a consequent increase in the cost of the economic extraction of the lead, gold, and silver. (7) Iron and sulphur, and also iron, copper, and sulphur, in the mineral compounds known as pyrite, pyrrhotite, chalcopyrite, chalcocite, and bornite, when mixed with gold and silver ores, will greatly facilitate the economic metallurgical extraction of the gold and silver from the raw ore. (8) But an arsenical or an antimonial ore, having both combined gold and silver, could not be treated thus economically, for many exactly known chemical and metallurgical reasons.

27. (1) Under ordinary normal conditions of location and transportation, the minimum cost of the economic extraction and transportation, i.e., the fixed charges, of an ore which contains gold as a native metallic alloy with other metals (and which native gold can be obtained by simple crushing, then washing with water, and combining it with mercury on the quicksilvered plate and apron of an ordinary gold mill) is nearly $5 per ton (avd.). (2) When, however, gold is obtained as the by-product of a lead ore or of a copper ore, there may be conditions therewith that may make it profitable to extract it when even as lean as $1 per ton (avd.). (3) And when conditions are offered of cheap transportation of machinery and supplies, the gold ores themselves have been profitably mined and the ores economically treated when as low as $2 per ton (avd.), such as the ores in the Alaska-Treadwell and adjacent mines near Juneau, Alaska. (4) Another cheap form of extraction of gold from rock is when the gold metal (in the shape of grains, scales, and dust) is found in the rock detritus (or the broken and lixiviated rock material in the shape of gravel), where it can be economically extracted therefrom the gravel, by the simple hydraulic mining processes. The North Bloomfield Company, of California, has profitably extracted such gold metal from the said gravel when only carrying five cents to the ton, or as low as seven cents to the cubic yard of gravel, and paid dividends thereon its capital stock. (5) But the average cost of extraction of the gold metal from placer gravels by dredger mining is from four to seventeen cents per cubic yard of gravel; and (depending on the cost of installing and maintaining the necessary enormous water supply therefor) by the hydraulic mining methods is from three cents to twelve cents for a cubic yard of gravel. The cost of dredger mining in the Klondike on *unfrozen* gravel being about 20 cents a cubic yard.

28. (1) When gold is not found as a native metal, but as a true ore, in chemical combination with tellurium and oxygen, the mineral compound is then called a telluride of gold, and is named calaverite. When silver is also present with the tellurium and oxygen and gold, the mineral is named sylvanite. This class of ore, when of a high-grade character in the ore body, is so extremely valuable, that it requires a class of smelting process, the expense of which varies with the amount of gold content in the rock. With a very rich gold telluride ore, the metallurgical expense of extraction is much higher than when it is lean and scattered widely throughout the rock mass. This is due to the reason of the danger of the excess of the volatile oxide of tellurium present in the ore, in escaping with the air blast of the furnace, absorbing some of the molten gold, and carrying it away in the fumes from the furnace. (2) The normal expense of the smelting of gold metal, when in combination with the other ordinary gold, silver, lead, or copper ores, is from $4 to $8 per (avd.) ton of rock.

29. (1) Silver ores are usually found associated with lead ores and with copper ores, although it is sometimes found as a silver chloride ore (containing chlorine), and also found as native silver metal in hairs, scales, strings, and masses of metal among the rocks. (2) The silver metal is usually extracted as a by-product from the base copper metal and from the base lead metal. In some parts of Utah, Nevada, Mexico, and Peru it is also mined as a direct silver ore, with a by-product content of both gold and copper. (3) Silver is usually obtained by refination of the bars of base lead and base copper that come from the smelting furnaces. There should be at least one ounce of silver metal to the ton of normal copper ore to make the resultant bar of concentrated copper sufficiently rich in silver to economically extract it therefrom. (4) There should be at least two ounces of silver metal to a ton of lead ore (and it more often needs fully ten ounces) to make the resultant bar of concentrated lead ore sufficiently rich in silver to economically extract it therefrom. (5) The smelting charges for ordinary silver ores are about the same as for ordinary gold ores.

30. (1) Lead ores are quite simple of metallurgical extraction, but in order for lead ores to be economically and profitably mined, they must possess a minimum content of lead at about 10 per cent of their rock mass; but they are often found as rich as fully 65 per cent of lead in their ore mass. (2) The ordinary silver-lead ores, that when concentrated and sent to the smelter for reduction usually contain about 65 per cent of lead, 30 ounces of silver, and a tenth of an ounce of gold. (3) The smelting charges are about the same as for ordinary gold and silver ores, and in certain localities about two-thirds of this cost.

31. (1) Copper ores usually necessitate 7 to 10 per cent of the copper metal in the rock mass to make them economical of profitable metallurgical extraction. However, when they also contain combined gold and silver ores, and are in favored localities for transportation, they have been mined at a profit, even as low as only 2 per cent of the copper metal. But when they are below 4 per cent of copper metal in the rock mass, they are usually called too lean in copper to be profitable to mine. (2) When, however, the copper is found as a native metal, as in the peculiar amygdaloidal rock mass, such as occurs in the Lake Superior region, and together with exceptionally favored transportation facilities, then as low as three-fourths of one per cent (or only 15 pounds [avd.] of copper metal to the ton of the rock mass) has been profitably mined. (3) But this low extraction of profitable copper metal is only accomplished by the most economic and efficient scientific engineering and metallurgical management, that is found in any part of the mining world, and therefore cannot be cited as an example for ordinary individual mining operators to follow, as a minimum limit of economic copper metal extraction from the rock mass. (4) The smelting charges are about the same as for gold, silver, and lead ores; but, when including the subsequent refining charges, the cost of producing a pound of pure copper for the market is about nine cents.

32. (1) Zinc ores should have not less than 20 per cent of zinc metal, so that when concentrated to their highest point of economic separation, they should give about 60 per cent of zinc metal in the furnace. (2) The metallurgical treatment of zinc ores is more of a distilling and condensing process than a strict smelting process like that used for lead, copper, silver, and gold ores. (3) The furnace treatment expense of the reduction of ores of zinc varies with the richness of the zinc ore in zinc metal. It is somewhat higher in price than the ordinary smelting cost for gold, silver, lead, and copper ores, and an additional cost for refining the crude zinc.

33. (1) Tin ores range from one to three per cent of tin metal to one ton of the quartz granite that they are usually found in. (2) Stream tin is the concentrated tin ore (cassiterite when as a tin oxide, and stannite when as a tin sulphide) from the broken and lixiviated granite rocks that it was originally deposited in, that are found in placer gravels. (3) In order to make it profitable to obtain stream tin from placer gravels by means of the ordinary hydraulic mining processes, there should be at least one per cent—20 pounds (avd.)—of stream tin to the cubic yard of gravel. (4) Tin concentrates are usually sent to the smelter containing about 70 per cent of the tin metal, which has afterward to be refined from the other contained metals by a poling process with sticks of green wood or by a pouring process. The cost therefore of smelting tin ores is about three times higher than for gold and silver ores; and all of the American tin concentrates are usually shipped to Antwerp for treatment and refination.

34. (1) Aluminium ores, when sold on the open market as corundum, beauxite, emery, and cryolite, usually range from 30 to 55 per cent of the aluminium metal. (2) But, as I have previously stated, the cost of separating the oxygen and silicon from the aluminium ores is so excessively great, that unless the operator has access to very cheap transportation for his raw ores, and has very cheap electric energy to produce the necessary chemical and thermic conditions to economically extract the aluminium metal therefrom, he had better sell his aluminium ores direct as an abrasive material (such as emery and corundum) rather than attempt to extract the metallic aluminium. (3) The patents for the economic extraction of aluminium metal from the raw aluminium ores being controlled by a very rich and powerful syndicate is another condition which makes it impossible for any individual mining operator to economically extract the metal therefrom. (4) The smelting and electrical furnace cost of metallic extraction therefore is several times greater than for gold and silver ores.

35. (1) Nickel ores for profitable mining should contain not less than 2 per cent of nickel metal in the rock mass. (2) Nickel is usually found as a by-product in some silver ores; but it is also found as a native mineral accompanied with sulphur and arsenic. Nickel is also found combined with oxygen, silicon, and magnesium, as a bisilicate of nickel and magnesia; and is also nearly always present in the meteoric masses of metallic iron, to sometimes as high as 8 per cent of the meteoric iron mass. (3) Cobalt ores are nearly always found associated with nickel ores, and both nickel and cobalt are very closely related in nearly every chemical, electrical, and magnetic condition with iron. (4) Their cost of metallic extraction is several times higher than for gold and silver ores.

36. Mercury ores, as cinnabar, are used to make valuable red pigments, and for varied chemical and medicinal uses. The liquid metal, called quicksilver, is extracted from the ores by a process of furnace distillation. For metallurgical purposes, mercury is used as a mercury-silver pasty alloy on sheet silvered copper, as a plate or apron in front of the battery box of gold stamp mills, to absorb and dissolve the gold metal flowing over the quicksilvered plates along with the water and crushed free gold ores from the battery box of the stamp mill. Mercury is also used, when alloyed with tin, in the making of mirrors; and is used for various other purposes in the commercial arts, and also in chemical, medicinal, and physical laboratories for many other purposes and uses of importance.

37. (1) Antimony ores and arsenic ores are not considered of very much metallic importance. They are usually obtained as unimportant by-products in the

metallurgy of smelting other metallic ores. (2) Arsenic, as a hard and brittle metal, has no practical commercial uses, except in certain limited uses. Its mineral and chemical compounds with oxygen and sulphur are used, however, to some extent as pigments and poisons. (3) Antimony as a metal is used for making type metal and for the hardening of lead, tin, and zinc for various purposes, but its commercial uses as a metal are not nearly so useful as lead, tin, or zinc.

38. Chromium has only one distinct ore, which usually contains about 42 per cent of the chromium metal. From this chromium ore we obtain valuable pigments and an intensely hard alloy along with iron and manganese.

39. Manganese ores usually have 42 to 55 per cent of manganese metal. They are very often associated with iron ores. Manganese, nickel, cobalt, and iron are very closely related in all their chemical and physical affinities, one with the other. From manganese we can make a valuable alloy with iron, that is useful for many varied commercial purposes.

40. (1) Platinum, as a native metallic alloy with iron, iridosmine, etc., has been found as high as one-half ounce per ton (avd.) in a certain class of rocks, but is then of a very rare type of mineral compound. It is usually found as an alloyed metal in Russian and Brazilian placer gravels, averaging about the one-fortieth part of an ounce to the cubic yard of gravel. (2) It is usually magnetic when found in its native state, due to its alloyed iron content. It is nearly always associated with iridosmine, iridium, ruthenium, and palladium, and sometimes is found with the ore of tantalic oxide. The latter-named metals, however, have only specialized commercial values, and are rarely ever in quantity sufficient to be seen outside of physical laboratories. (3) From the metal tantalum (as well as from the metal tungsten) we can obtain a brighter glowing incandescence in an electricized vacuum lamp than with any other metals in such vacuum lamps, the metallic tungsten giving forth in an electricized vacuum lamp an intensely white light, with a corresponding minimum consumption of electric energy in proportion to the light.

41. Tungsten, bismuth, cadmium, selenium, barium, molybdenum, vanadium, uranium, and tellurium as metals have a very restricted usefulness. The future of tungsten, however, in electrical light purposes seems very bright. From tungsten we can make pigments, and a valuable hard alloy with iron; and also a most intense and vivid white light, when in an electric-energized vacuum lamp, greater than the light emitted from tantalum. From cadmium we can obtain yellow pigments. From ores of uranium we can obtain bright yellow pigments, and also the rare auto-radio-active elements called radium and polonium. From bismuth, we can greatly lower the melting points of all the compounds of alloys with the other metals that it enters into. From barium ores, we can obtain a white, very heavy earth, which is used to adulterate lead and zinc pigments. From molybdenum we can make a valuable alloy with iron, and a valuable chemical reagent for the laboratory. From tellurium we can make an alloy so brittle that a trifling part of a per cent of tellurium will make even ductile gold or platinum as brittle as common glass. From vanadium we can make beautiful red or black pigments, and a strongly tensile alloy with iron. With palladium we can make a white alloy, and a non-magnetic spring and screw for watches. With selenium we can produce an electro-responsive action in the light, and a non-electro-responsive action in the dark; therefore, metallic selenium is used for various purposes of transmitting electric energy and for a certain kind of telephones and photophones, and also to carry electric energy to explode a certain kind of submarine torpedo, and also for measurement of the quantity of the energy of the Röntgen rays, in therapeutic applications.

42. (1) We now come to the last rock or mineral compound, and, as is usually the case, "the last shall be first," especially in its commercial economic value. (2) Iron ores are really more important to mankind than all of the other ores which we can obtain from the rocks of the crust of the earth. (3) Take away iron, and I very seriously question whether our present methods of civilization could continue to exist; because we have not sufficient of the other metallic minerals (even if they were all combined) to take the place of iron for the purposes of economic, structural, and motive work. (4) An iron ore should have at least 35 per cent of iron metal to be profitably treated in the furnace. But, owing to the large amount of the high grade iron ores that we have in America and the economic transportation of these rich iron ores to the furnaces, the average percentage of the iron ores that are smelted in America ranges about an iron ore having fully 60 per cent of iron metal. (5) A pure iron oxide (as a ferric sesquioxide, $Fe_2O_3$) can be as rich as 70 per cent of iron metal; but 68 per cent is about as rich as is ever concentrated and sent to the iron furnaces for extraction of the iron metal. There is also a higher oxide of iron which contains (when pure) over 72 per cent of the iron metal, but it is not usually found in mass sufficient to be called a smelting ore of iron. (6) The actual cost of smelting iron ores into pig iron is about $8 to $10 per ton of pig; and an additional cost of $2 per ton to convert the pig iron into steel. The actual cost of steel rails at the steel mills in America is about $11 to $13 per ton, and about $18 in Europe. (7) The economic value of a mine of iron ore depends very materially on the important question of cheap transportation of the ore to the smelting furnace, as well as the cheap transportation to the smelting furnace of the flux and fuel, or the necessary limestone and coke, which is used to extract the oxygen from the iron ore, and allow the iron content to sink down through the melted limestone and incandescent coke, so as to form an impure metallic mass of itself, which is called pig iron.

43. (1) In the concentrates of placer gravels, containing tin stone (stream tin) and gold dust (metallic gold), there are usually found more or less quantities of monazite. This is a mineral which sometimes contains as high as seven per cent of a very rare metal, called thorium. (2) All of the thorium minerals are powerfully responsive to radio-activity when in near contact with auto-radio-active compounds, and will also glow or shine with great brilliancy when in the emanation or atmosphere emitted from burning gaseous hydrogen and carbon compounds. The Welsbach light and the Nernst light are examples of this kind of intense illuminating activity.

44. The rarer elements, such as coronium, helium, argon, actinium, polonium, radium, etc., are found in such very infinitesimal amounts in the minerals of the rocks that they cannot be taken into consideration at all when speaking of the metals that we can in a commercial sense economically obtain from the rocks of the earth's crust.

45. (1) Although coal is not a "metal," and is not, therefore, strictly speaking, as directly related to the rocks of the earth as are the ore veins, yet coal is one of the most valuable metamorphic mineral compounds that are found among the surface rocks of the earth's crust; for we cannot conceive, as geologists, that such a high-carbon compound as coal is, can exist at very great depths below the surface of the earth in a solid state, but must, by the interterrestrial heat, change into liquid and gaseous carbon compounds. (2) It is presumed that coal is formed from carbonized vegetation by the concentration (by pressure and heat) of the carbon contained in the original vegetable matters. This carbon concentration is supposed to have been caused by the pressure of the overlying sands and silts on a submerged bog of vegetable matter, creating heat sufficient to soften the vegetable matters and being out of contact with atmospheric oxygen to combine with the carbon is thus freed from nearly all of its combined water, and changed into all grades of coal compounds, from fibrous peat to bituminous coal, to crystalline anthracite, and to even foliated graphite, along with its impurities of silica, alkalies, iron compounds, and sulphur. (3) That is, from vegetable matters (first formed by the combined action of sunlight, air, water, and rock) we have peat, then lignite, then bituminous coal, then anthracite coal, and then graphite; and the crystallizing of the graphite into a true rock or crystal would then produce the diamond. But it is thought, however, that diamonds are produced by the escape of the oxygen from gaseous carbonic acid, in the magma of molten volcanic rock or volcanic aqueous mud, and the subsequent crystallizing of the remaining carbon by enormous interterrestrial pressure, forming the rock crystalline form of coal, to which we have given the name of diamonds. (4) The actual carbon content of the rocks, as a mass, is very small indeed, being only fifteen one-hundredths of one per cent of the total mass of rocks. (5) In the United States the first recorded discovery of coal was made by Father Hennepin in 1679 on the Illinois River. The first coal mined in Virginia was in 1748. Anthracite coal was first mined in Pennsylvania in 1790. Over 50 per cent of the total production of coal from the United States was mined in the State of Pennsylvania from 1807 to 1907.

46. Another carbon compound is petroleum. This is usually an oily chemical mixture of carbon and hydrogen with some sulphur. It may have been formed during seismic convulsions and consequent volcanic thermal energy, by the action of gaseous magmatic hydrogen, combining with the concentrated carbon of an intensely heated and interterrestrially liquefied deposit, of any class or form of coal compound. But there are many serious objections to this statement, although it is a possible, practical method of the genesis of petroleum.

47. Natural gas may practically be called an impure gaseous ether of petroleum, freed from the heavier oily carbon-hydrogen compounds, as it nearly always overlies or is adjacent to a deposit of the oily petroleum.

48. Bituminous rock, bituminous shales, and certain varieties of cannel coal, are practically porous rocks or earthy, sandy, or alkaline matters, more or less saturated with the solid residue of petroleum.

49. Asphaltum, bitumen, and mineral pitch are practically the more or less dried natural residues of certain kinds of petroleum, after the more volatile natural gas has been eliminated by heat.

50. Ozokerite, paraffine, and mineral wax are the hard and concentrated fatty, waxlike residues of the naturally evaporated petroleum.

51. Gilsonite, elaterite, grahamite, and other related carbon compounds are evidently certain forms of the solid residue of various forms of a naturally evaporated kind of tarry petroleum, either pure or mixed with arenaceous, or argillaceous or calciferous matters.

52. (1) Salt (or what we usually speak of as domestic salt) is a compound of the alkaline metal called sodium with the volatile gas called chlorine. It is therefore called the chloride of sodium. (2) The per cent of chlorine in the rocks of the crust of the earth —as we are able to get them and to analyze them— is only about the one-hundredth part of one per cent, while the sodium content, in the surface rocks of the earth, is 2 67/100 of one per cent, or 267 times as much as the chlorine.

53. Gypsum is a compound of sulphur and lime; that is, a compound of sulphur, oxygen, and calcium.

54. Sulphur is found in the rocks of the earth at about the proportion of seven one-hundredths of one per cent. Sulphur is also found native as an impure crystallized sulphur on the cooled walls of volcanic vents, and is also found combined with various metalliferous ores, as sulphides and sulphates.

55. Phosphorus is found in the rocks of the earth combined with other elements, in a condition called phosphates. Phosphorus is about the nine one-hundredths of one per cent of the total mass of the surface rocks of the earth.

56. Fluorine, lithium, and strontium are each about the one-hundredth part of one per cent of the total rock mass of the crust of the earth.

57. Barium is about three one-hundredths of one per cent of the surface rocks of the earth.

58. Titanium is about thirty one-hundredths of one per cent of the surface rocks of the earth.

59. (1) And this practically concludes all the available substances that we can extract from the rocks of the available surface crust of the earth. (2) Of the many other mineral compounds and rare metals that we have daily access to, they can only be classed as below the hundredth of one per cent and into the thousandths of one per cent of the total mass of the rocks of the available crust of the earth. By available I mean that part of the surface crust of the earth that we can economically get access to.

(To be continued.)

## MINE FIRES; THEIR EXTINGUISHMENT BY SULPHUR DIOXIDE.*

By WALTER O. SNELLING.

IN combating mine fires the use of carbon dioxide as a means of producing an atmosphere in which combustion cannot be sustained, has been many times suggested, and frequently tried, generally with a fair degree of success. The cost of producing carbon dioxide has been, however, a decided drawback, and the danger of producing carbon monoxide by the reduction of the carbon dioxide by heated carbon, and consequently bringing about an explosion, has also tended to prevent this method from being used.

The use of sulphur dioxide in combating mine fires has not, I believe, been previously suggested or tried, and yet the method presents such decided advantages over the use of carbon dioxide, that I now suggest the advisability of considering it as a cheap, convenient, and safe means for fighting stubborn mine fires, and I herewith present some statements to show the advantages which this method would possess.

Cost, Production, etc.—Sulphur dioxide is produced by the simple burning of brimstone on a grate of suitable kind, and of such nature as could be quickly constructed, even by inexperienced men. One ton of brimstone, costing $40, will produce 25,000 cubic feet of gas, and allowing for all sources of loss, it is probable that sulphur dioxide can be produced for $2 per 1,000 cubic feet. For carbon dioxide, produced by the action of sulphuric acid on limestone, the best estimate I have been able to figure is about $4 per 1,000 cubic feet, or twice as costly as the sulphur dioxide.

Efficiency.—Sulphur dioxide is more efficient than carbon dioxide in the putting out of fire. Neither coal nor any other combustible material can possibly burn in an atmosphere containing any considerable quantity of sulphur dioxide. Sulphur dioxide is very heavy, being almost twice as heavy as carbon dioxide (1 cubic foot weighing 81 grammes, while 1 cubic foot of carbon dioxide weighs 46 grammes) and consequently the sulphur dioxide will penetrate into gob piles, and in every way serve as an efficient agent in finding its way into

* From a paper read before the American Institute of Mining Engineers.

every part of the region of the mine into which it is introduced.

Safety.—None of the dangers incident to the use of carbon dioxide are present with sulphur dioxide. No explosive lower oxides are produced, or can be produced by the reduction of sulphur dioxide. Still more important, the danger always present when using carbon dioxide, of men getting into the gas without knowing of its presence and suffocating, is absent when sulphur dioxide is used, since its strong odor gives instant warning when but a small fraction of one per cent of the gas is present in the air.

Other Advantages.—Any leakage of carbon dioxide from a mine can only with great difficulty be detected. Frequently, in places where this method has been applied, it is probable that millions of cubic feet of the gas have escaped through unknown fissures in the rock. Any leakage of sulphur dioxide would quickly make itself known, and the openings could accordingly be closed before more than a small portion of the gas had escaped.

## LIQUID SOAP—AN ECONOMICAL FORMULA.*

By M. I. WILBERT.

MANY of the advantages that would accrue from the use of liquid soap, in hospital wards and in public places generally, are so self-evident that it will not be necessary for me to reiterate them at this time. The detergent properties of this form of soap, combined with the general sense of safety and cleanliness that must accompany the use of an absolutely fresh particle of soap at each using, are perhaps the more prominent among the evident reasons why, when once introduced, the use of liquid soap is destined to displace the cake variety in public lavatories and in practically all places where two or more persons are expected to use the same soap.

One of the objections to the more widespread use of liquid soap, even at the present time, is the comparatively high cost of this form of preparation, largely due to the cost of the ethyl alcohol necessary in making the solution.

Methyl alcohol, while cheaper, offers serious objections, and its use, in view of the many reported cases of untoward results even from the inhalation or the external application of comparatively small quantities, is not permissible.

Being desirous of securing a liquid preparation with a minimum of alcohol, a series of experiments were inaugurated that resulted in the apparent discovery that a mixture of soda and potash soaps is much more soluble in water and much more stable, in any given dilution, than either one of its constituents.

Elaborating on this discovery, we have devised a formula that produces a uniformly satisfactory product, and one that, made from purified cotton-seed oil, will not cost more than fifty cents a gallon, buying in quantities such as an ordinary retail druggist would be likely to use.

The formula now in use is as follows:

| | |
|---|---|
| Sodium hydroxide | 40 grammes |
| Potassium hydroxide | 40 grammes |
| Cottonseed oil | 500 c.c. |
| Alcohol | 250 c.c. |
| Distilled water, sufficient to make | 2,500 c.c. |

In a suitable container, preferably a glass-stoppered bottle, dissolve the potassium and sodium hydroxides in 250 cubic centimeters of distilled water, add the alcohol, and then add the cottonseed oil in three or four portions, shaking vigorously after each addition. Continue to agitate the mixture occasionally until saponification has been completed. Then add the remaining portion of distilled water, and mix.

The only precautions that are at all necessary is to use U. S. P. grade of ingredients and to be sure that saponification is complete before adding the remaining portions of the distilled water. The water used must be absolutely free from soluble salts of the alkali earths or the heavy metals, and for this reason should be, preferably, freshly distilled.

The resulting preparation not being official, the pharmacist is at liberty to modify the formula to suit his own individual taste or the preference of his customers. The soap can, of course, be readily made more alkaline, and it can also be made with an appreciably smaller quantity of the alkali.

For general use as a toilet soap it would, of course, be necessary to give it some distinctive odor. This can best be accomplished by replacing a portion of the water with distilled extract of witch hazel, rosewater, or orange-flower water, or, by adding the necessary perfume, spirit or essential oils to suit the individual taste or need. A satisfactory odor, and one that offers a good taking point, might be secured by using a mixture of essential oils used as the flavoring ingredients of the alkaline antiseptic of the N. F. or the liquid antiseptic of the U. S. P.

These few suggestions should suffice to indicate that there is practically no limitation to the possibility of varying the resulting composition or the odor of this soap, and the price at which it can be produced, even in small quantities, should be an incentive for retail pharmacists to develop a demand for a preparation of this kind and to supply the resulting wants of his customers himself.

* Read at the recent meeting of American Pharmaceutical Association.

## ENGINEERING NOTES.

**The Times** (London) states that the Danish government is considering a project to construct a railway tunnel under the Great Belt. The total length of this tunnel would be about 17 miles, of which 12 miles would be under the sea. The estimate of the cost is put at slightly more than $7,000,000. At the present time, there is a train ferry service across the Belt, but it is often handicapped by bad weather, and it is calculated that the tunnel service would be profitable, even if the cost were considerably more than the estimate given. Test borings have shown that the condition of the materials in which the tunneling work would have to be carried out is favorable for the work.

**Consul-General Richard Guenther,** writing from Frankfort, says that during the past year the shipyards of Germany were well employed. He gives the following facts: There were built 435 steamships, with a total of 311,105 gross register tonnage, and 516 sailing vessels, aggregating 57,337 gross register tonnage, while 203 steamships (369,172 gross register tonnage) and 270 sailing ships (47,015 gross register tonnage) were on the stocks in course of construction at the end of 1907. Of the steamships turned out and in course of building 38 were men-of-war, having a total of 128,088 gross register tonnage. In addition, 67 steamships (162,278 tons) and 145 sailing vessels (38,650 tons) were either built or in course of building at foreign shipyards for German account last year. As an offset to this, 112 steam and sail vessels were built in German yards during the past year for foreign countries. There were still on the stocks, at the end of December, 29 steam and sail ships (total 13,600 tonnage) which were ordered by foreign customers. The outlook for German shipbuilding interests in 1908 does not appear so promising, foreign trade and business in general taking a relatively downward course.

**Emil Capitaine,** who died recently, was regarded as one of the foremost engineers in Germany in the development of a "gas producer" for ship use. Messrs. Thornycroft some time ago secured the English rights for his design, and at this time Messrs. Beardmore of Scotland have completed an engine of the marine type of between 500 and 600 horse-power, and have another engine under construction of larger power. This latter engine will approximate 2,000 horse-power, but on this point nothing is known definitely. Messrs. Beardmore state that they are at present experimenting with the completed engine, but find that there are many points requiring careful consideration before they can declare themselves ready to put their work in the market, points that have more to do with producers than engines. It should not be long, however, before the Beardmore experiences are available, when some interesting data may be expected. The Capitaine system is already in service to a considerable extent in Europe, and where employed the suction gas plant is utilized. This service, it must be understood, is with small craft.

**The first American** glass factory was erected in the town of Temple, N. H. Washington, in his diary, speaks of glass being made in New Haven, Conn., in the year 1789. One would suppose by the language he uses that he considers it a new and quite extraordinary affair. It was nine years previous to this, and during the very war whose issue first enabled the country to commence its own manufacturing, that Robert Hewes, of Boston, began to carry out the project which he had long conceived, but had hitherto found impracticable, if not impossible, under English rule—that of making glass in America for America. In 1780 Mr. Hewes selected a site for his factory secure from the British forces (his glassblowers were Hessians and Waldeckers—soldiers who had deserted from the British army), and he must have had an eye for the beautiful in nature. He chose a spot on the north slope of Kidder Mountain, near its base. To the northwest Mount Monadnock rears his granite crown, standing like a giant sentinel; to the north, and running east, are the Temple Mountains, bold and precipitous; to the east a beautiful valley holds in its embrace the towns of Wilton, Milford, and Nashua, while to the northeast Joe English Hill and the Uncanernucks Mountains conceal the city of Manchester. The place is now reached by a two-mile walk over an old road, long a stranger to travel other than by grazing cows and nature-loving tourists. The stone work about the ovens and the foundations of the building are all that now remain to remind us that here was another example of the American people's struggle for independence.—Crockery and Glass Journal.

## TRADE NOTES AND FORMULÆ.

**Rubber Shoe Varnish.**—Caoutchouc (rubber) 70 parts, purified pine rosin 140 parts, oil of turpentine 250 parts, bone black 20 parts. The turpentine and the rubber are first heated to a pretty good temperature together, allow the rosin to melt in the mixture and stir the bone black into the still hot mass.

**Adhesive Grosolin.**—*a.* 5 parts of potato starch, 6 parts of water, 0.25 part of nitric acid are allowed to stand for 48 hours in a warm place, and then boiled until we obtain a thick fluid, very translucent syrup, which is filtered. *b.* 5 parts gum arabic, 1 part sugar, 5 parts water, 0.05 part of saltpeter, heated to complete solution. The fluids obtained as described under *a* and *b* are mixed.

**White Glaze for Bricks or Tiles.**—

| | I. | | II. | |
|---|---|---|---|---|
| Lead ash | 12 | or | 16 | parts |
| Litharge | 4 | or | — | parts |
| Quartz sand | 3 | or | 5 | parts |
| Clay | 4 | or | — | parts |
| Common salt | 2 | or | — | parts |
| Powdered glass | 3 | or | 4 | parts |
| Saltpeter | 1 | or | — | parts |
| Loam | — | or | 1 | part |

By adding 20 parts of tin ash to 100 parts of lead ash and litharge, we obtain a glaze of a still more perfect white.

**To Apply Gold to Ivory and Glass.**—1. The pattern (ornamentation) is traced with a fine camel-hair brush, moistened with chloride of gold. Then the glass or ivory is held over the mouth of a flask in which hydrogen gas is in process of generation (by the action of dilute sulphuric acid on zinc waste). The hydrogen reduces the chloride of gold on the painted places to metallic gold, and the film of gold thus deposited will soon develop quite a shine or glitter. The gold film is very thin. 2. Another process (only for glass). Gold powder is prepared by rubbing down gold leaf with a little honey or thick mucilage or gum fluid in a porcelain dish until the gold is completely transformed into powder, after which the honey or gum, by repeated additions of warm water and pouring it off again, is washed away. The gold powder is then mixed with a strong borax solution, with which mixture the pattern is traced. When it is dry, place the glass in an oven and expose it to very considerable heat. This causes a sufficient amalgamation of the borax and the glass, so that the gold is firmly attached to the latter.

**Enameling Hollow Objects.**—The castings are cleansed, pickled in a dilute solution of sulphuric acid, and scoured with sand, dipped in warm water and dried. They are then ready to receive the grounding coat: 30 parts by weight of finely ground, dry quartz; 22.5 parts of crystallized borax and 7.5 parts of fine fluorspar are fused in a clay crucible, so that a mass of 68.5 to 69 parts is produced, which after careful sorting is pulverized. 16 parts of this fused mass is then mixed with 6.5 to 12.5 parts of quartz, 4 to 5 parts of gray clay, and 0.5 part of borax. While this is being rubbed up with water, 2.5 parts of clay and 0.66 part of borax must be added. Make an addition of water. This is applied with a brush, dried, and burned (yellowish brown). After cooling, the glaze is applied in the form of a thin wash: 25 parts of fluorspar, 1 part of oxide of zinc, 4.75 parts of oxide of tin, 0.75 part of bone ashes, and 0.03 to 0.05 part of smalt. Of this mixture, 9 to 9.25 parts is mixed with 16 parts of felspar, 9 to 9.75 parts of crystallized borax, 3.25 parts of crystallized soda, and 1.25 to 1.50 parts of saltpeter. The whole is transferred to a fireproof crucible, having a hole in the bottom, through which the molten mass flows into a vessel placed under the furnace grate. The cooled mass is then rubbed up fine with water, and to each 30 parts 6 pieces of white clay, each about 80 parts by weight (say $2\frac{1}{2}$ ounces each) is added and 0.03 part of zinc oxide. The mass is applied with a brush, dried and exposed to a sufficient degree of heat.

## TABLE OF CONTENTS.

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